DOCUMENT RESUME

ED 149 956 SE 022 617

TITLE Science Syllabus for Middle and Junior High Schools. Living Systems: Block B, Human Systems.
INSTITUTION New York State Education Dept., Albany. Bureau of General Education Curriculum Development.; State Univ. of New York, Albany.
PUB DATE [77]
NOTE 80p.; For related document, see SE 022 616

EDRS PRICE MF-$0.83 HC-$4.67 Plus Postage.
DESCRIPTORS *Biology; *Course Content; Course Objectives; *Junior High Schools; Middle Schools; *Objectives; Performance Criteria; Physics; Science Education; Secondary School Science; *State Curriculum Guides; State Departments of Education

ABSTRACT

This publication is the second product of a project to update and reorder the Science Syllabus for Middle and Junior High Schools in the State of New York. The performance criteria and objectives are provided in a general outline in the first section, which conforms to the content subdivisions in the three "processes" sections: (1) Work and Energy, (2) Energy in Humans and Living Systems, and (3) The Application of Physical Principles to Life Functions. These three sections share the same format of "Concepts and Understandings" and their corresponding "Questions and Activities." A list of processes is also included as is a large appendix of learning activities. The publication is designed so that the understandings, questions, and learning activities are enhanced by the inclusion and referencing of program objectives, performance criteria, and process skills. Environmental considerations are infused throughout and the importance of consumer and career implications in a science program is specifically acknowledged. This syllabus could be adapted to a variety of science education situations. (MR)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

Science Syllabus for Middle and Junior High Schools

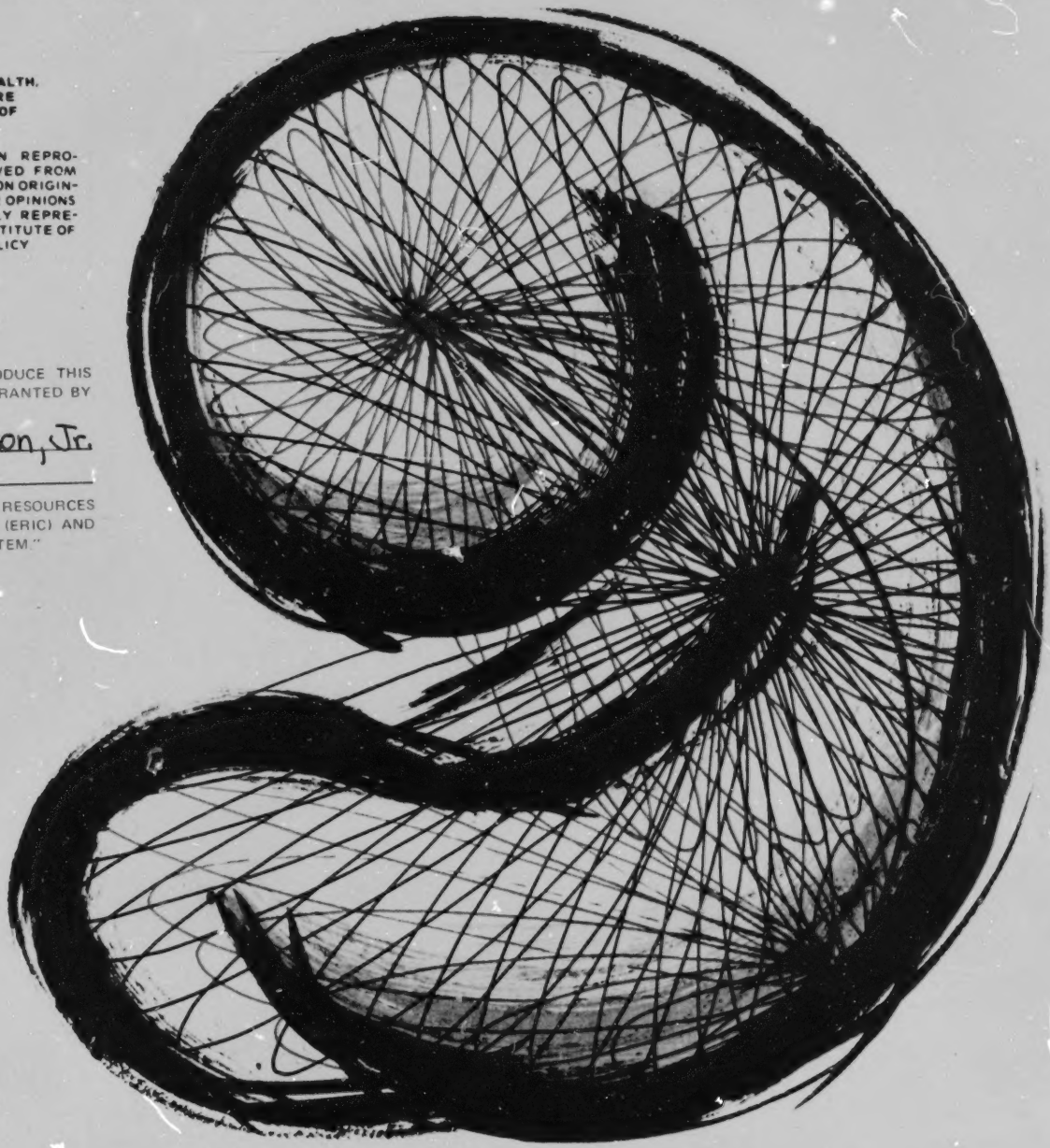
U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Gregory Benson, Jr.

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."



ED149956

HUMAN SYSTEMS

LIVING SYSTEMS block B

2

SE 022 617

SCIENCE SYLLABUS

FOR

MIDDLE AND JUNIOR HIGH SCHOOLS

BLOCK B

LIVING SYSTEMS: HUMAN SYSTEMS

The University of the State of New York
THE STATE EDUCATION DEPARTMENT
Bureau of General Education Curriculum Development
Albany, New York 12234

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of The University (with years when terms expire)

1981 Theodore M. Black, A.B., Litt.D., LL.D., Pd.D., D.C.L., L.H.D., Chancellor - Sands Point
1987 Carl H. Pforzheimer, Jr., A.B., M.B.A., D.C.S., H.H.D., Vice Chancellor- Purchase
1978 Alexander J. Allan, Jr., LL.D., Litt.D.- - - - - - - - - Troy
1981 Joseph C. Indelicato, M.D., L.H.D. - - - - - - - - - - - Brooklyn
1986 Kenneth B. Clark, A.B., M.S., Ph.D., LL.D., L.H.D., D.Sc.- Hastings on Hudson
1983 Harold E. Newcomb, B.A.- - - - - - - - - - - - - - - - - Owego
1988 Willard A. Genrich, LL.B., L.H.D., LL.D. - - - - - - - - Buffalo
1982 Emlyn I. Griffith, A.B., J.D.- - - - - - - - - - - - - - Rome
1977 Genevieve S. Klein, B.S., M.A. - - - - - - - - - - - - - Bayside
1981 William Jovanovich, A.B., LL.D., Litt.D., L.H.D. - - - - Briarcliff Manor
1983 Mary Alice Kendall, B.S. - - - - - - - - - - - - - - - - Irondequoit
1984 Jorge L. Batista, B.A., J.D. - - - - - - - - - - - - - - Bronx
1982 Louis E. Yavner, LL.B. - - - - - - - - - - - - - - - - - New York
1979 Laura B. Chodos, B.A., M.A.- - - - - - - - - - - - - - - Clifton Park
1980 Martin C. Barell, B.A., I.A., LL.B.- - - - - - - - - - - Great Neck

President of The University and Commissioner of Education
Ewald B. Nyquist

Executive Deputy Commissioner of Education
Gordon M. Ambach

Deputy Commissioner for Elementary, Secondary and Continuing Education
Thomas D. Sheldon

Associate Commissioner for Instructional Services

Assistant Commissioner for General Education and Curricular Services
Vivienne Anderson

Director, Division for Curriculum Services
Gordon E. Van Hooft

Chief, Bureau of General Education Curriculum Development
Herbert Bothamley

Director, Division of General Education
Ted T. Grenda

Chief, Bureau of Science Education
Edward T. Lalor

FOREWORD

This publication is the second product of the project to significantly update and reorder the Science Syllabus for Middle and Junior High Schools. The project will result in a group of instructional blocks encompassing the content and skills in the biological, physical, and earth sciences appropriate for the grade levels indicated above.

The understandings, questions, and learning activities in the publication have been enhanced by the inclusion and referencing of program objectives, performance criteria, and process skills which serve to focus student achievement. Thus, environmental considerations are infused throughout the content material and the importance of consumer and career implications in a science program is specifically acknowledged.

The objectives and performance criteria provided in the general outline on pages 1 through 3 conform to the content subdivisions in the publication; the process skills are keyed to the learning activities; and the learning activities are keyed to the understandings and the questions.

The development of this syllabus was coordinated within the Bureau of General Education Curriculum Development by Barry W. Jamason, associate. Gerald Cerne, South Colonie School District, revised portions of the content material while reviewing the entire manuscript. Joan Rosner, (retired) District 30, Queens, added environmental education understandings to the publication. Edward T. Lalor, Chief, Bureau of Science Education, and William A. Calhoun, (retired) associate in science education, reviewed all materials and made valuable suggestions for content improvement and accuracy. The cover design was created by Oscar A. Kaufman.

Herbert Bothamley, *Chief*
Bureau of General Education Curriculum Development

Gordon E. Van Hooft, *Director*
Division for Curriculum Services

CONTENTS

	Page
Foreword	iii
Program Objectives and Performance Criteria	1
Processes	4
I Work and Energy	5
A Work involves different forms of energy	5
B Work is related to specific kinds of energy	5
C Machines doing human's work	6
II Energy in Humans	7
A Source	7
B Supply	7
C Conservation	7
D Obtaining and storing fuels	8
E Consuming fuel	8
F Measuring energy	9
III Living Systems and the Application of Physical Principles to Life Functions	10
A Fundamental systems	10
B Maintenance systems	11
Appendix - Learning Activities	33

PROGRAM OBJECTIVES AND PERFORMANCE CRITERIA

The program objectives and performance criteria below are provided as an aid in ordering the direction and synthesizing the outcomes of the instruction related to this block. The objectives and outcomes (performance) described below for this program permit latitude in the selection of content. It is implied that student knowledge, understanding, and skills accrued as a result of content selection and instruction will be demonstrable in the manner, and to the minimum extent described.

Program Objectives	*Performance Criteria*
I. WORK AND ENERGY	
The student will be able to describe the work and energy interrelationship and cite examples of potential and kinetic energy.	Given an example where work is being accomplished, the student should be able to identify the form of energy related to the work. Given a form of energy, the student will classify it as potential or kinetic.
The student will be able to describe current energy sources in terms of their significance to society and their environmental implications.	Given a conventional energy source, the student will classify the source as renewable or nonrenewable. Given a situation involving energy generation from a nonrenewable source, the student will cite possible alternative sources and conservation principles involved.
II. ENERGY IN HUMANS	
The student will be able to describe the role of food in human growth and energy production by citing sources of nutrients, their storage, and energy yields in the body.	Given a list of foods the student will identify the available nutrients. Given the calorie amounts for various foods, the student will classify such foods according to their energy yield.
The student will be able to describe the energy transfers in a food chain and predict the results of poor conservation practices.	Given a food source, the student will identify the environmental conditions needed to sustain the source. Given appropriate food pyramids, the student will cite those high in animal protein and cite the difficulties inherent in providing such food sources for the world's population.

Program Objectives	*Performance Criteria*
III. LIVING SYSTEMS AND THE APPLICATION OF PHYSICAL PRINCIPLES TO LIFE FUNCTIONS	
The student will be able to identify and characterize the interrelationship of the three fundamental systems (structures) which make up the human body.	Given a fundamental structure, the student will identify the function of that structure and its relationship to other structures in the system.
The student will be able to identify the various human maintenance systems, their parts and functions in the operations of the body.	Given a maintenance system, the student will identify the structure(s) of the system and their function. Given a situation describing a stimulus and a response involving the human body, the student will describe the maintenance systems that interacted to produce the response.
The student will be able to identify those elements and practices that hinder proper functioning of the various body systems.	Given an appropriate environmental situation harmful to the human body, the student will identify the system(s) affected. Given an appropriate case history citing an environmentally hazardous situation, the student will identify the choices to be made.
Throughout this program the instructor should be cognizant of the importance of including several related objectives and performance criteria which represent the practical infusion of career and consumer considerations as they relate to science education:	
The student will be able to demonstrate an awareness of the contribution to society which is being made by persons who have elected careers and occupations which are allied with the subject matter.	Given the name of a career or occupation related to the subject matter, the student will describe the contributions to society made by the able execution of such career or occupational activities.
The student will be able to describe the career and occupational opportunities and the knowledge, skills, and attitudes helpful in those careers and occupations related to the subject matter.	Given a career or occupational classification related to the subject material, the student will describe activities carried out in this work. Given an occupational role related to the subject material, the student will describe the training and aptitudes required to perform the role.

Program Objectives	*Performance Criteria*
	Given an opportunity, the student will describe currently practiced work habits, skills, and knowledge that relate to careers implied in the subject material.
The student will be able to describe the economic implications for society of understanding the concepts of work, energy, production, consumption, conservation, systems, maintenance, and efficiency.	Given an example of energy production and consumption in terms of the human body, the student will demonstrate understanding by constructing a parallel in terms of society's production and use of energy.
	Given a maintenance system of the human body, such as the digestive system, the student will describe the proper functioning of the system in light of the manner in which society's marketplace provides items for human consumption.

PROCESSES

One of the major objectives in all science courses is the development of competence in processes used in science. The learning activities in this publication will assist students in attaining this objective. Each activity is keyed to one or more of the processes listed below. For example, activity (B-1) involves processes [10], [9], and [8]. In general, the processes are listed in order of predominance within the activity and appear to the right of the activity's title.

[1] Observing objects and phenomena

[2] Describing observations

[3] Selecting suitable measuring instruments

[4] Developing skills in using laboratory equipment

[5] Measuring objects and phenomena

[6] Performing laboratory techniques

[7] Estimating measurements within limits of accuracy

[8] Recognizing a problem

[9] Formulating a working hypothesis

[10] Designing appropriate tests of a hypothesis

[11] Designing suitable procedures for experimental tests

[12] Processing experimental data

[13] Organizing data to show a functional relationship

[14] Interpreting observations and data

[15] Interpolating and extrapolating

[16] Evaluating a hypothesis in the light of data obtained

[17] Formulating generalizations based on relationships

[18] Recognizing the need for a theoretical model

[19] Formulating a theoretical model to accommodate knowledge

[20] Designing relationships satisfied by a model

[21] Deducing a hypothesis from a theoretical model

[22] Interpreting and evaluating tests of a model

[23] Producing a revised, refined, or extended model

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
I Work and Energy	
All forms of energy may be harnessed to do work. Energy is the capacity for doing work.	
A Work involves different forms of energy	
One form of energy may be transformed into another.[1]	*How may some forms of energy be changed into other forms?* (B-1, B-2, B-3)
	What progress is being made in scientists' efforts to convert solar energy into heat and electricity?[2]
Work is done when there is movement against a resisting force or when a body is made to move faster or slower.	*How can we measure the forces acting upon a body?* (B-5, B-6)
Since work is done when a force overcomes a resistance and moves something, work may be quantitatively described as the product of a force and the distance through which the force moves in the line of action.	
Weight is the force of gravity that the earth exerts on an object and is measured in pounds or newtons.	
Force is a push or pull on a body. Examples of units of force are the pound and the newton.	
B Work is related to specific kinds of energy	
All forms of energy may be divided into two kinds: potential energy and kinetic energy.	*How are potential and kinetic energy related?* (B-4)

---

[1] All forms of energy are related to some kind of motion. Some forms of energy are transmitted as waves.

[2] The sun has always been the indirect source of most of the energy used by man (food supplied by green plants and animals; work of domesticated animals; fossil fuels to power machines; energy of wind). Increasing shortages of conventional sources of energy have led to a search for methods of changing the sun's energy directly to heat and electricity, and to the production of other energy sources such as hydrogen and methane.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
Either kind of energy may be converted into the other. These two conversions are continually occurring.	
1 potential	
Potential energy is the energy which a body has because of its position or form. When a spring is compressed or a bow is bent, potential energy is stored up. When an object is lifted, the energy it has depends on the mass of the object and the distance the object has been elevated against the force of gravity.	
2 kinetic	
Kinetic energy is the energy which a moving body has because of its motion. The amount of energy depends on the mass of the moving body and how rapidly it is moving.	
C Machines doing human's work	
Society has grown increasingly dependent on energy sources other than human to do its work.	*How have changes in life-style during the 20th century led to substitution of nonrenewable energy sources for human and animal energy?*
Individuals must become well-informed about the best ways to manage and conserve our energy supplies.	*For example, what kinds of energy are involved in the manufacture and use of some ordinary objects found in the home or school?*
As natural resources become scarcer, the inexhaustible supply of human energy, resolve, determination, and ingenuity must be fully utilized.	*What environmental problems have resulted from the increased use of powered machines?*[3]

[3]Man's unthinking overuse of machines and the energy to power them has led to a tangled web of environmental ills: depletion of nonrenewable resources; water and air pollution from drilling oil wells and generating electricity; damaged landscapes resulting from strip-mining; noise pollution from automobiles and machinery; congested highways and urban sprawl from an automobile-oriented society.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
II Energy in Humans	
A Source	
Within an ecosystem, energy is captured and transferred by the activities of green plants. Since human energy requirements are met primarily by the body's oxidation of food, humans are dependent upon other organisms, beginning with green plants, through food chains and food webs.	*How is energy transferred in a food chain?* *What is a food web?* *What is the position of humans in a food web?*[4]
B Supply	
Energy, as a prime environmental component along with space, water, air, and food, may become a limiting factor to human survival since all living things are competing with each other for energy.[5]	*Which of a green plant's basic needs (sun, soil, water, air, and space) may become limiting factors as society becomes more urban, and as populations grow? Explain.*
C Conservation	
Energy and matter are neither created nor destroyed in reactions associated with the life processes but are passed on from organism to organism.	*How will man's food supply be affected if the world population continues to grow at its present rate?*
The resources which are the basis for energy for humans are vulnerable to depletion in quality and quantity and must be conserved.	
The demands of population growth coupled with a tremendous waste of energy are responsible for some of our more serious environmental problems. Society must develop the technological and sociological knowledge needed to control population growth, modify environments, and alter resource use patterns.	*What new career opportunities have developed in the area of conservation?*

---

[4]Humans are omnivores. They may select foods at any level of a food web. The most efficient level, in terms of full utilization of available energy, is that of primary consumer. Considerable energy is lost at each step in a food chain as the food is used to supply energy for the life activities of the consumer.

[5]Competition for available energy may take place between populations of different organisms occupying the same niche, or within a population when the supply of energy is too small to meet the demand.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
D Obtaining and storing fuels	
All living things grow by converting digested materials into the kind of substances which form the organism. All chemical processes that are involved in living organisms, including the storage or oxidizing of foods, are processes that occur in solution or in a dissolved state.	*How can we be assured that our diets provide us with the nutrients to keep our bodies functioning properly?* (B-7, B-8, B-9)
1 nutrients	
All foods are composed of one, or varying proportions of several, of the following classes of nutrients: carbohydrates, fats, proteins, minerals, and vitamins.	*Why are DDT and other fat-soluble pesticides more hazardous for animals, including man, at the top of the food chain than for lower animals?*[6] *How does the "pyramid of mass" show that a human diet high in animal protein is a luxury many countries cannot provide?*[7]
2 food additives	
Food additives are chemicals that food manufacturers add to their products. Some additives increase a food's nutritional value, while others merely improve the color, flavor, or texture of foods; still others keep food from spoiling.[8]	*How are the subsystems within the body affected by food additives and synthetic foods?*
E Consuming Fuel	
The human body is structurally adapted to store potential energy in various types of tissue, and to make this energy readily available when work is to be performed.	

---

[6]DDT, and other fat-soluble pesticides, are retained in an animal's fatty tissue rather than excreted. As biomass moves up the food chain, the amount of the poison is increased because the chemicals have been repeatedly concentrated.

[7]The existence of one or several intermediary consumers prior to the human level means that much of the original biomass of the plant producer is used in the body building activities of these lower animals. A diet high in plant products is much more efficient.

[8]Food additives can be classified into six major groups: (1) preservatives, (2) nutritional supplements; (3) flavoring agents; (4) coloring

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
1 oxidations	
Carbohydrates, fats, and proteins are oxidized in the body's cells and used as fuel for the production of energy. Additionally, proteins are used to build new tissue proteins.	*How do body cells oxidize digested food material to provide energy for the organism?* (B-10, B-11)
Living things need oxygen to release the energy stored in food.	*What effect could increasing pollution of air, water, and land have on the supply of available oxygen in the air?*[9]
2 energy yields	
The oxidation of simple carbohydrate (glucose) furnishes the main source of energy for muscular work, and furnishes the heat needed to maintain our body temperature.	
Carbohydrates and fats may be oxidized completely to form carbon dioxide and water which are normal body wastes.	
When we compare the amount of oxygen taken into our bodies with the amount of carbon dioxide given off during respiration, we can determine how efficiently our body cells are working.[10]	*How can the production of carbon dioxide be detected?* (B-12)
Protein may be oxidized to yield carbon dioxide and water as wastes, but additional wastes (urea and ammonia) are also produced. These are eliminated in the urine.	
F Measuring energy	
The energy of food is not used directly as heat, but is customarily measured in heat units (calories).[11]	*How is the energy value of foods measured?* (B-13, B-14)

---

agents; (5) emulsifiers, stabilizers, and thickeners; and (6) acids and alkalis.

[9]A balance between oxygen and carbon dioxide in the air is provided by the process of photosynthesis. This balance can be disturbed if photosynthesis in the oceans, which provide one-third of the world's oxygen, is interfered with by such abuses as sewage disposal, overexploitation of marine resources, and spills. In addition, the amount of oxygen produced by land vegetation can constantly decrease as larger numbers of green areas are urbanized and covered over with concrete.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
A calorie is defined as the amount of heat required to raise the temperature of 1 gram of water through 1 degree centigrade.	*What fuels does man use in his machines to produce energy?* *What is a British Thermal Unit?*
III. Living Systems and the Application of Physical Principles to Life Functions	
The human body is an intricate, organic system which is itself composed of a variety of systems, each with an interdependence of function which contributes to the operation of the system as a whole.	
There are parallels between life support systems in a human community and in the human body.[12]	*What are some of the most important life supporting systems in a human community?*
A Fundamental systems (structures)	
1 cells	
There are many kinds of cells, but each kind of cell is structurally adapted to perform one specific role better than others.	*What are the smallest units of living matter?* (B-15)
Most cells consists essentially of a growing area (cytoplasm) and an area which controls most of the cellular functions (nucleus).[13]	*What can we discover about the physical properties of cytoplasm?* (B-16)
2 tissues	
Tissues are composed of similar cells which perform a specific function. (Skin is a tissue.[14])	*What is tissue?*

Finally, the balance between oxygen and carbon dioxide in the air can be further upset as increasing amounts of carbon dioxide pour into the air through the burning of coal, oil, and gasoline.

[10]The ratio of the volume of oxygen consumed to the volume of carbon dioxide produced (during quiet respiration) is directly related to our basal metabolism and indirectly related to how well our thyroid gland functions.

[11]The amount of energy that can be obtained from oxidizing one gram of carbohydrate (glucose), one gram of fat, or one gram of protein is approximately 4 calories, 9 calories, and 4 calories respectively.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
3 organs	
Organs are composed of similar or dissimilar tissues. Organs act together as a unit to form a system. Systems perform certain functions such as digestion and circulation.	*How are the various tissues and organs coordinated?* (B-19)
In all living things, the more complex the organization, the greater is the differentiation, division of labor, and the dependence of one structure upon the performance of another.	*How are organs integrated into organ systems?* (B-20)
Cells are organized into tissues, tissues into organs, and organs into systems.	
B Maintenance Systems	
1 skeletal system	
The skeletal system provides support for the body's organs and the means for its locomotion.	
a functions	
Hunans and other vertebrates have a very efficient system of support in the form of an internal skeleton, or endoskeleton, which performs the following functions: (1) to provide support for the other orgars of the body; (2) to protect internal organs; (3) to store minerals; (4) to provide a surface for muscle attachment; and (5) to manufacture red blood cells and certain white blood cells.	*Explain how the skeletal system protects body organs.* *How do muscles and bones move the body?* (B-21) *How do bones supply the body with blood cells?* *How did coal-fired furnaces contribute to widespread incidence of ricketts in Dickensian England?*[15]
b structure	
The skeletal system consists of bones, cartilage, and ligaments which are connective tissues serving to bind together many softer tissues, giving them firmness.	

---

[12]Air, water, and energy sources enter the human community through highly organized arteries and networks. They are utilized by the community in a series of distinct but interrelated life support systems, and wastes generated in these processes are returned to the air, water, and land.

[13]The cytoplasm in living active cells is a dynamic, moving material. This movement (cyclosis) may be speeded up or slowed down by warming or cooling processes. Many structures

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
	Why were the effects of strontium-90 contained in radioactive fallout during the 1950's considered one of the important reasons for banning nuclear testing?[16]
(1) skeleton	
The skeleton is composed of the skull, the spinal column, the breastbone and ribs, and the limbs.	*What functions are performed by the bones of the skull?* (B-22) *What functions are performed by the backbone?* (B-23)
(a) bones	
The sizes and shapes of the bones of the skeleton are closely related to their functions. Long bones act as (first or third class) levers in the body. Flat bones such as those in the skull have special adaptations (sinuses) which afford lightness to the skull and resonance to the voice. Irregularly shaped bones (vertebrae, wrists, and foot) provide a maximum of support and flexibility of motion.	
(b) cartilage	
A softer material than bone, cartilage is present at the ends of many bones. It also acts as a cushion and it lends rigidity to structures that lack bones (outer ears, tip of nose).	

---

within the cytoplasm are carried along with the movement of cytoplasm in which they are suspended.

[14]It is believed by many scientists that fluorocarbon compounds released by aerosol and refrigerants are not destroyed in the lower atmosphere, but rise instead into the stratosphere where they are decomposed by ultraviolet radiation from the sun. This decomposition releases free chlorine atoms which gradually cause a decrease in the amount of ozone in the stratosphere. The ozone normally found in the stratosphere shields the earth from harmful amounts of ultraviolet radiation. A decrease in the ozone present could lead to an

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
(c) ligaments and tendons	
Ligaments and tendons are dense, fibrous connective tissues which join muscles to bone or bone to bone to aid in movement.	*How do ligaments bind the ends of bones together?* (B-24)
	How do tendons enable us to move? (B-24)
(2) joints	
The junctions between bones are called joints and are of two major types: movable (ball and socket joint - hip; pivot joint - between skull and first vertebra; gliding joints - between vertebrae; hinge joints - elbows, knees, fingers) and immovable (cranium).[17]	
A distinctive structural adaptation, the opposable thumb, has made humans more of a threat to the environment than any other animal.[18]	

NOTE: The sub-topic, "bones at work," is frequently treated as an optional elaboration upon the study of the skeletal system, and as an opportunity to develop the concept of bone movement as a manifestation of basic physical principles which also apply to simple machines. For this reason, activities B-25 through B-34 are provided in the Appendix in support of the teacher who exercises this option.

2 muscular system (locomotion)	
The power of contraction which results in movement is possessed by all protoplasm to a greater or lesser degree.	
A large blood supply is necessary for most muscles since they require large amounts of energy-supplying nutrients in addition to a way of disposing their wastes.	*How is energy related to the contraction of our muscles?*

---

increase in the incidence of skin cancer.

[15]Smog caused by coal-fired furnaces hung over 19th century English cities, blocking out the sun's ultra-violet radiation. This radiation is needed to activate the formation of vitamin D, which is necessary for the development of strong, healthy bones.

[16]Strontium is an element closely related, and similar in action, to calcium. It can be taken up by grasses, which in turn are eaten by cows and absorbed in their milk. Both calcium and strontium are deposited in growing bone tissue. Strontium-90 is a radioactive form of the element with a dangerously long half-life. It can cause bone cancer, leukemia, and genetic abnormalities.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
Muscles function poorly when fatigued, when the blood supply is diminished, or when the efficiency of nerve transmission is decreased.	*How do we store some of the energy-supplying nutrients that our muscles require?*[19]
(1) skeletal muscle cells	
Skeletal (striated) muscle cells are long and slender, are attached to bone, and are adapted to voluntary control.	*What are the physical characteristics of skeletal and smooth muscle cells?*[20]
(2) smooth muscle cells	
Smooth (involuntary) muscles are short, slender, and are usually wrapped around or imbedded in tissue where an automatic squeezing action is required.	
(3) cardiac muscle cells	
Cardiac muscles are similar to striated cells except that they are interconnected in the form of a network. The whole network contracts entirely upon stimulation and is adapted to involuntary control.	
b functional applications	
Muscle fibers move when stimulated by nerve impulses and by other physical or chemical means.	*How do skeletal muscles move the skeleton?* (B-28)
Muscle fibers have the power of contraction and relaxation.[21]	*What is peristalsis?* (B-36)
3 nervous system (response)	
All living things respond to environmental stimuli and in most complex organisms there is differentiation of tissue which is particularly well-adapted to perform a specific function.	

---

[17]The synovial membrane envelops highly movable joints. It secretes a viscous, mucin-like fluid which lubricates the articulating surfaces.

Ball and socket joints are adapted to afford angular motion (with a pivoting action) in all directions. Pivot joints are rounded so as to allow rotation in one axis. Gliding joints are structurally adapted so that the rubbing surfaces accommodate each other (bones of the wrist). Hinge joints allow angular motion in one plane only.

[18]The opposable thumb makes possible the use of the tools and instruments which have enabled man to modify his environment according to his own

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
The nervous system and glands help to regulate and coordinate all body activities.	*How are the activities of the body controlled?* (B-37)
a structure	
The numerous, interrelated nerve cells of man form a complex system through which every organ of the body is connected to every other organ.	
Nerve cells are so arranged that they permit a message to travel along a nerve in one direction only.	
b function	
The nerve cells (neurons) which form nerve tissue are well-adapted to transmit messages from one location to another. The transmission of impulses along nerves is considered an electrochemical phenomenon.[22]	
Sensory nerves are adapted to receive messages and transmit the sensation to the spinal cord or brain.	*How are messages transmitted to the brain or spinal cord?* (B-37)
Motor nerves are structurally oriented to direct messages to muscles to cause movement or to glands to cause them to secrete.	
Associative nerve cells are structurally oriented within the brain and spinal cord to permit the interconnection between sensory and motor nerves.	
c central nervous system	
The central nervous system consists of the brain and spinal cord, each of which performs specialized functions (differentiation and division of labor).	

needs and demands. All of the miracles, and the environmental mistakes, of human civilization - architectural, technological, agricultural, artistic - are the result of the dexterity given man by his opposable thumbs.

[19]The hepatic portal system enables energy-supplying nutrients (glucose) to reenter the blood and to be returned directly to the heart for their subsequent distribution throughout the body.

[20]Skeletal muscles are arranged in the body so that they are antagonistic to each other. When one contracts another relaxes permitting purposeful movements (biceps and triceps).

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
(1) brain	
Humans have the most highly developed brain in the animal kingdon, giving them a heightened ability to think, reason, and create.	
(a) cerebrum (thought processes)	
The cerebrum functions in remembering, reasoning, and speaking. It is the control area for seeing, smelling, tasting, hearing, and touching.	
(b) cerebellum (balance and muscle coordination)	
The cerebellum receives messages from sensory nerves and the semicircular canals. These messages are integrated with motor messages transmitted to the muscles and result in smooth, coordinated movements. (The biceps contract at the same time that the triceps relax.)	
(c) medulla oblongata (initiating automatic vital responses)	
The medulla oblongata controls involuntary acts, such as the heartbeat and breathing.	*How does the central nervous system coordinate body activities such as breathing?* (B-38)
(2) spinal cord	
The spinal cord carries messages between the brain and other body structures and serves as a center for many reflex actions (reflex arc).	

---

[21] Many muscle fibers resist stretching. Their automatic contractions are partly due to the force of gravity; for example, jaw and abdomen muscles.

[22] Special nerve systems (sympathetic, parasympathetic) seem to be in sympathy with our basic needs. These systems usually send rhythmic messages to certain involuntary muscles, such as those located in the blood vessels, the digestive tube, certain skin glands, striated muscles which oppose gravity or are necessary for respiration, and cardiac muscles controlling heart action. Body temperature and protective actions are controlled by these nerves.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
d understanding how we learn	
All learning processes are fundamentally related to our ability to perceive sensations.	
(1) perception - messages from the external environment	
Our senses of sight, smell, hearing, taste, and touch function to provide us with the external features of an object.	*How do our senses provide us with information about our surroundings?* (B-39, B-40, B-41, B-42, B-43)
	How have our senses of sight, hearing, smell, and taste been bombarded by disturbing messages as a result of environmental pollution?[23]
	In what ways has environmental pollution actually distorted some of our senses?
	What are some examples of ways in which other animals have more highly developed and sensitive sense receptors than humans?
(2) memory - previous experiences	
In order to learn new things we must relate these things to previous experiences.	*How do we learn?* (B-44, B-45, B-46)
(3) reason	
Reason is the power of comprehending, inferring, or thinking in orderly, sensible, rational ways by which process knowledge is advanced beyond what is already "known."[24]	

[23]Visual pollution, noise, air filled with offensive odors, waterways smelling of hydrogen sulfide, and tasting of strong chemicals used to purify polluted rivers - all have contributed through our senses to a perception of a deteriorated environment. Air pollution causes eyes to tear and be veiled. Smog and haze result in poor visibility. Excessive noise levels can lead to hearing impairment.

[24]By reasoning inductively, we are able to project our thoughts to arrive at general principles or laws by examining individual or particular things. Deductive reasoning allows us to analyze general principles so as to

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
To make judgements we must mentally decide between two or more distinct concepts.	*How do we make judgements?* (B-48)
(4) behavior (inborn)	
Every animal comes into the world possessing certain inherited behavior patterns which function automatically and serve for its protection.	*How can a better understanding of behavior help us solve problems?* (B-47)
(a) simple reflex action	
Simple reflexes are inborn reactions which are unlearned and independent of intelligence.	*How do "unlearned acts" serve for our protection?* (B-49)
Reflexes are important in controlling the everyday vital functions of the organism.	
(b) instincts	
Instincts are inborn patterns of behavior.	
(5) behavior (acquired)	
(a) conditioned responses	
Conditioning is the changing or modification of behavior patterns due to an association between different kinds of stimuli.	*How may we condition or bring about changes in the behavior of animals?* (B-50)
In the conditioned reflex, there is a substitution of a new stimulus for the original stimulus.	
Unwarranted fears and prejudices are encouraged by certain kinds of conditioning.	
(b) habits	
Habits are responses to stimuli which become automatic as a result of constant repetition.	*How are habits formed?* (B-51)

---

arrive at other general principles or to particulars which might be a basic part of a generalization. Intuitive thinking involves immediate understanding; it is a mental "leap" which may frequently provide the wrong conclusion.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
Habits may be helpful or harmful.	*What are some of the reasons people fall into the habit of drug abuse either through use of narcotics, tobacco, or alcohol?*
(c) voluntary acts - a desired response	
Voluntary or willful acts involve some kind of intelligence. Such acts include memory, reasoning ability, speed of recognizing symbols, space perception, and possibly others.	*How does the study of animal behavior help us understand our own behavior?* (B-52)
Intelligence may be described partially as an ability to solve problems in situations new to the individual.	
4 endocrine system (ductless glands)	
The endocrine system is made up of glands and their secretions (hormones). The endocrine system and the nervous system function together to coordinate and control the body activities.	*How do endocrine glands coordinate the functions of the body?*
The endocrine glands are made up of tissue which is specialized to secrete hormones directly into the blood. The hormones regulate growth and development and help control metabolism.	*Where in the body are the endocrine glands found?* (B-53)
a thyroid	
The thyroid hormone regulates the rate of metabolism.	*What effects would an underactive thyroid have on the body. What would be the effects of an overactive thyroid?*

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
	What effect can radioactive iodine in the air have on the thyroid gland?
b parathyroids	
The parathyroid hormone regulates the use of calcium in the body which is important for nerve function, blood clotting, and the proper growth of teeth and bones.[25]	
c adrenals	
There are a number of adrenal hormones, one of which (adrenalin) functions during times of stress.	*What conditions may increase the flow of adrenalin?*
d pituitary	
The pituitary secretes many hormones which influence other endocrine glands and regulate growth of the skeleton.	
e pancreas	
The pancreatic hormones influence the sugar level in the blood.	*Why do doctors test urine samples for the presence of sugar?*[26]
f sex glands	
Testes are the male gonads which are found in the scrotum.	
Ovaries are the female gonads which are found in the abdominal cavity.	

[25] If the calcium level in the blood becomes too low, violent involuntary muscular contractions and convulsions occur.

[26] The disease diabetes mellitus occurs when not enough insulin is released by the pancreas resulting in an increase of sugar in the blood. Some of this excess sugar is removed by the kidneys and thus will be found in the urine. Administration of insulin and careful control of carbohydrates (sugars and starches) in the diet is included in the proper treatment of diabetes.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
The sex hormones influence the reproductive functions and the secondary sex characteristics.	*What are some secondary sex characteristics?*[27]
5 digestive system	
Human organisms have special adaptations for making food soluble and for reducing nutrients to simpler form.	*Where and how are foods digested?* (B-54)
a structure	
The digestive system consists of the mouth, esophagus, stomach, and the small and large intestines.	
b the digestive process	
(1) digestion in the mouth	
The digestive process begins in the mouth which contains structures that function to increase the surface area of solid foods.	*How does chewing prepare food for digestion?* (B-55)
Mastication by the teeth breaks the food (solute) into smaller pieces which are then exposed to a dissolving medium (solvent) from the salivary glands.	*What are the properties of a solution?* (B-56) *What factors affect the rate at which substances will dissolve?* (B-57, B-58) *How are carbohydrates acted upon by the saliva?* (B-59) *Why are starches converted into sugars in the digestive process?* (B-60)
(2) peristalsis	
Peristalsis is the process by which successive waves of involuntary contractions move food through the digestive tract.	

[27] Female secondary sex characteristics include the growth of breasts and widening of the hips. Male secondary sex characteristics include a deep voice, larger masculine body form, and facial hair.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITES
When food leaves the mouth and enters the esophagus, a series of rhythmic, wave-like contractions (peristalsis) pushes food further down the esophagus and into the stomach. These contractions move liquified food from the stomach to the small intestine, and later move undigested or undigestible matter from the small intestine to the large intestine.	*How is food moved through the digestive tract?* (B-36)
(3) digestion in the stomach	
Food is digested or changed into soluble form by the action of glandular secretions (enzymes) of the stomach wall which aid in dissolving proteins.[28]	*How is food broken down into soluble substances by certain chemicals in the body?* (B-62)
(4) digestion in the small intestine	
The digestion of food and the absorption of dissolved nutrients into the blood stream occur primarily in the small intestine.[29]	*How does digested food enter the blood?* (B-63, B-64)
The small intestine has finger-like projections called villi which are specially adapted to perform the absorption of food (fatty acids, amino acids, and glucose) into the blood stream for distribution to the body cells.	*How do food nutrients pass through all membranes to nourish body cells?* (B-65)
(5) the large intestine	
The lining of the large intestine absorbs moisture and passes it into the bloodstream.	
Bacteria live off organic substances in the large intestine and synthesize vitamins, such as B_{12} and K, which are useful to the body.	

[28] Circular (sphincter) valves at the entrance and exit of the stomach function automatically to allow small amounts of food to enter and leave the stomach. These adaptations prevent regurgitation and keep food in the stomach long enough for partial digestion of proteins.

[29] Involuntary muscle fibers are oriented lengthwise and circularly throughout the walls of the small intestine in order to provide automatic motion of food substances in one direction.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
Undigested and indigestible material constitute the wastes (fecal material) which move automatically through the large intestine.	*Compare human digestion with digestion in green plants.* (B-61)
c ingested poisons	
Many harmful substances find their way from the environment into the human digestive system.[30]	*How do dangerous chemicals find their way into the human digestive system via the family "market basket?"* *How do the Food and Drug Administration and the Environmental Protection Agency protect consumers from eating poisons with their normal diet?* *Why does "pica" (the habit some young children have of eating nonfoods) cause serious harm when paint is eaten?*[31] *What is the Safe Drinking Water Act?*[32]
6 transport system	
Circulation occurs in all living things, but more complex organisms also have special adaptations for fluid distribution.	
a diffusion	
The exceedingly small particles (molecules) which make up all matter are constantly in motion. This incessant motion enables molecules to go into the spaces between the molecules of other substances.	*What are some evidences that matter is made up of tiny invisible particles which are in motion?* (B-66)

---

[30]Some commercially processed foods contain residues of carcinogenic pesticides. Raw fruits and vegetables, if not properly washed, may be covered with poisonous insecticides. Chemicals contained in some pesticides build up in the food chain, contaminating finfish and shellfish. Mercury, which enters bodies of water with industrial waste, or is washed off vegetation dusted with fungicides, enters the human body with fish.

[31]Most house paint is lead based. In some substandard dwellings where old paint has flaked off, children have contracted acute lead poisoning by eating it in large quantities. Lead can cause anemia, severe intestinal cramps,

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
Osmosis is a type of diffusion which takes place through a semipermeable membrane.	*How do some molecules spread out and diffuse between the molecules of other substances?* (B-67, B-68)
When a semipermeable membrane separates two fluids of different densities, molecules will move in both directions through the membrane. The greatest rate of flow will be from the more dense to the less dense media until equilibrium is reached.	*How do some molecules pass through semipermeable barriers?* (B-69, B-70)
b human circulation	
The heart, blood, lymph, arteries, veins, capillaries, and lymph vessels make up the circulatory system.	*How is blood distributed throughout our bodies?*
The transport of digested materials, glucose, urea, water, oxygen, and carbon dioxide to and from all the cells of the body is the function of the circulatory system.	*How do nitrites, sometimes used as meat preservatives, affect the circulatory system?*
(1) heart	
The heart acts as a pump structurally adapted to receive blood at low pressure and to emit blood at high pressure for distribution throughout the body.[33]	*How is the heart adapted to pump blood throughout the body?* (B-71)
The heart's muscle fibers are arranged so that when they contract (rhythmically, at a rate controlled by messages from the medulla oblongata) they lessen the capacity of the chambers they enclose.	*What effects might prolonged exposure to high decibel sound levels have on the heart's function?*
Blood is received into the two receiving chambers of the heart, the atria, and then discharged from these two chambers simultaneously during contraction when the valves	*What can heart sounds tell us about our circulatory system?* (B-73)

---

nerve damage, and even death. A special Federal law, the Lead-Based Paint Poisoning Prevention Act, governs lead levels in paints, and empowers HUD to regulate lead paints already on walls.

[32]The Safe Drinking Water Act of 1974 empowers the government to set drinking water standards for toxic substances. Final regulations are scheduled to be promulgated before September 1977. One especially alarming aspect of drinking water contamination under study in setting standards for the Safe Drinking Water Act is related to water chlorination. Recent events have indicated that some chemicals entering waterways as industrial waste, farm or city

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
(tricuspid and bicuspid) into both the right and the left ventricles are open.	*What causes the pulse rate to change?* (B-75) *What structural adaptations help to keep our blood flowing in one direction?*[34]
The left ventricle is about three times as muscular as the right ventricle since it must push blood throughout the body while the right ventricle directs blood only as far as the lungs.	
(2) the blood circuits	
The heart forces 3 to 4 liters of blood to the arteries of the body each minute.[33]	
Similarly, a large opening in the left ventricle leads to the largest artery, the aorta, whose branches transport blood to all the other body systems.	
The semilunar valves at the base of each of these arteries prevent the backflow of blood into the ventricles.	
(a) pulmonary circulation	
The pulmonary artery, coming out of the right ventricle, branches into two in order to carry blood to the right and left lungs. The completion of this blood circuit when blood from the lungs is returned to the left atrium of the heart by the pulmonary veins is known as the pulmonary circulation.	
(b) systemic circulation	
System circulation refers to the movement of blood from the left ventricle,	

---

storm runoff, or treated sewage discharges combine with the chlorine in drinking water to form chloroform or other chlorinated hydrocarbons. Some of these are thought to be carcinogenic.

[33]The heart forces 3 to 4 liters of blood to the arteries of the body each minute.

[34]Valves (such as the bicuspid, tricuspid, and semilunar) are structural adaptations which prevent the backflow of blood between the atria and ventricles and between the ventricles and outgoing blood vessels.

into the aorta, to all body systems except the lungs, and then to the right atrium of the heart via the large veins, the superior vena cava and inferior vena cava.

(3) blood vessels

(a) arteries

Arteries are the large vessels which transport oxygenated blood (except for the pulmonary artery) away from the heart in spurts as a result of the pressure from the heart and the action of the arterial muscle.[35]

What property of liquids makes the transmission of pressure possible? (B-72)

(b) veins

Veins carry smooth-flowing blood containing less oxygen (except for the pulmonary veins) to the heart. The major veins are the superior vena cava, the inferior vena cava, and the pulmonary veins.

How can we locate some of the valves in our veins? (B-74)

(c) capillaries

Capillaries, the most abundant blood vessels in the body, pass through tissues and organs to connect arterioles (the small branches of arteries) and venules (the small branches of veins), completing the circuit of blood.[36]

What is the effect of temperatures on capillary size? (B-76)

(4) composition of blood

Blood is a tissue composed of different types of cells suspended in an intercellular, fluid substance known as plasma.

What is the composition of the blood? (B-77)

(a) plasma

The liquid part of the blood, plasma, contains dissolved nutrients, wastes, salts, gases, and chemical regulators which are either being transported to or from body cells.

---

[35]The pressures at which blood travels along the arteries depends upon the force of the heart's (ventricular) contraction, the elasticity of the arteries, and the resistance that the vessels offer to the flow of blood.

[36]Capillaries are thin-walled (usually one cell layer), non-muscular, semipermeable tubes through which materials are exchanged by osmosis and diffusion.

(b) red blood cells (erythrocytes)

These cells have chemical adaptations which insure the transportation of oxygen to body cells.

How does the deadly air pollutant, carbon monoxide, affect the human body?[37]

(c) white blood cells (leucocytes)

These cells have the capacity for seeking out foreign particles such as bacteria and viruses, thus protecting the body from disease.

(d) blood platelets

Platelets are small cells formed in the bone marrow which play an important part in blood clotting.

7 respiratory system

Respiration is the release of energy from the oxidation of food within an organism's cells.

Most organisms use oxygen and give off wastes in the form of carbon dioxide and water during this process.

a structure

(1) nose

Air is inhaled through the two openings in the nose, the nostrils (nares), and into the nasal passages. The mucous membrane lining these passages moistens the air and traps dust and bacteria. Cilia projecting from the epithelial cells of this membrane move mucus containing dust and bacteria toward the nostrils from whence it is expelled.

---

[37] Carbon monoxide is absorbed by the lungs, and reacts with the hemoglobin in the circulating blood. The absorption of the carbon monoxide leads to a reduction in the oxygen-carrying capacity of the blood. It also cuts back on the readiness with which the blood gives up available oxygen to the tissues. Long exposure to carbon monoxide can lead to structural changes in the heart and brain. Excessive amounts can lead to death.

(2) trachea

From the nasal cavity, air passes through the pharynx and enters the trachea, or windpipe. This air tube is constructed so as to stay open at all times, and is supported by bands of cartilage which prevent it from collapsing. The upper part of the trachea is the larynx (Adam's apple) which contains the slitlike entrance to the trachea, called the glottis. Located above the glottis is the epiglottis which prevents food from entering the trachea and blocking the passage of air.

How is the voice produced? (B-78)

(3) bronchi

The trachea divides into two large branches, each of which (bronchus) passes into a lung.

(4) lungs

The lungs are two spongy organs, each covered by a protective double-layered membrane, the pleura. The bronchi branch into ever smaller tubes within the lungs called bronchioles which in turn open into the alveoli, or air sacs. The cells of these air sacs are the true respiratory surface of the lungs.

How are the lungs structurally adapted to serve us? (B-79)

Once the air is dispersed throughout the lungs by the air sacs, oxygen passes into the blood through capillaries which envelop the sacs. This oxygenated blood for the tissues reaches the heart via the pulmonary veins. Deoxygenated blood is brought to the lungs by the pulmonary artery.

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
b function	
(1) breathing	
Breathing is an automatic process by which air is drawn into and then expelled from the lungs. During this process, carbon dioxide in the lungs is exchanged for oxygen in the air. The *rate* of breathing is controlled largely by the amount of carbon dioxide in the blood.[38]	*How do we know that air exerts pressure?* (B-80) *How is atmospheric pressure related to the mechanics of breathing?* *What effect does the nature of our activities have upon the breathing rate?*
The functions of breathing are the: exchange of gases, elimination of wastes; regulation of body temperature; and, regulation of body water content.	*How do our bodies obtain air?*[39] *How much air can our lungs hold?* (B-81, B-82)
(2) stages of respiration	
Human respiration can be divided into three stages: (a) the breathing movements and the exchange of gases between the air sacs of the lung and the bloodstream (external); (b) the exchange of gases between the blood and the body cells (internal); and (c) respiration occurring within the cells (cellular).	*How are gases exchanged and wastes eliminated through the breathing process?* (B-83)
c the environment and the respiratory system	
(1) air pollution and the respiratory tract	
Pollutants and contaminants in the air are produced by natural and manmade processes.	*How do air pollutants affect the structure and function of the upper respiratory tract?*[40]

---

[38]The lungs do not have any structural adaptations (muscles) for contracting. Inflation and deflation is passive and results from differences in internal and external pressures. Muscular adaptations, such as the dome-shaped diaphragm and the muscles between the ribs (intercostals), help to increase the volume of the chest cavity when these muscles contract.

The diaphragm possesses circulatory arranged muscle fibers which shorten and cause the diaphragm to flatten out upon contraction.

[39]The act of inhaling or of expelling air is governed by changing the volume of the chest cavity. Contraction of the diaphragm and

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
	What effect can the energy crisis, and the resultant return to the use of coal and high-sulphur content oil, have on the body's responses to infectious diseases?[41]
(2) acute and chronic lung diseases	
Physical well-being is a fundamental necessity for survival even though man places a higher value on other things.	*What economic goals, for example, does society place ahead of the health and well-being of individuals?*
Man currently faces the prospect of endangering his chances of a better life through the very measures he employs to achieve it.	*What evidence exists to show a relationship between air pollution and such lung diseases as pneumonia, bronchitis, asthmatic bronchitis, emphysema, and lung cancer?* *How is the respiratory system affected by each of these diseases?*
(3) cigarette smoking and health	*What effect is smoking believed to have on the respiratory system?* *What changes, if any, have occurred in our country's smoking habits since a link was established between cigarette smoking and cancer?* *What are cocarcinogens?*[42]

---

rib muscles increases thoracic volume. The internal pressure is consequently reduced below atmospheric pressure and air rushes into the lungs. Relaxation of the diaphragm and rib muscles decreases the thoracic volume. Internal pressure is increased above atmospheric pressure and air is forced out of the lungs.

[40]Studies indicate that the irritants found in polluted air may change both the structure and function of the respiratory tract, thereby altering the body's reaction to infectious disease. Specifically, the irritants can: (1) slow down, and even stop, cilia action; (2) cause increased production of mucus; (3) paralyze bacteria-destroying cells in the respiratory

CONCEPTS AND UNDERSTANDINGS	QUESTIONS AND ACTIVITIES
(4) occupational health hazards	
In order to preserve our threatened environment, present attitudes must change to reflect a widespread public concern which will encourage protective action by individuals, groups, and the government.	*Why is it difficult to establish a definite link between industrial hazards and lung disease?*[43]
	Which occupational hazards affect the respiratory system?[44]
8 excretory system	
Through the functioning of the excretory organs (skin, lungs, kidneys, liver, and large intestine), metabolic wastes are removed from the blood and, eventually, the body.[45]	*What action has the government taken to regulate the methods, used by communities in disposing of human-body wastes?*[46]
a skin	
The main function of the sweat glands of the skin is to lower body temperature. In so doing, the glands also help in the elimination of wastes such as water, salts, and nitrogenous substances.[47]	*How are wastes eliminated through the skin?* (B-84)
b lungs	
The large number of air sacs in the lungs afford a large surface area from which gaseous wastes (carbon dioxide and water vapor) diffuse into the external environment.	
c kidneys	
The large filtering surface of kidney structures permits the elimination of water, urea, and other nitrogenous wastes which are in the bloodstream and to maintain the correct water balance in the body.	*How do kidneys aid in the elimination of wastes?* (B-85, B-86)

---

system; (4) induce swelling or excessive growth of the cells lining the airways; and (5) make breathing more difficult.

[41]Sulphur compounds, alone or in synergetic combination with particulates, are among the most hazardous of the air pollutants in their effects on the respiratory tract. A return to the use of coal and high-sulphur content oil can mean an increase in these pollutants in the ambient air unless adequate emission controls are established.

[42]Cocarcinogens are chemicals, some of which may not be carcinogenic if existing alone, but which multiply the risk of cancer when occurring together. For example,

d liver

The liver removes from the bloodstream worn-out red blood cells and excess amino acids.

e large intestine

The large intestine eliminates the solid wastes of the digestive process, but it also aids in removing from the body the excess salts (metabolic wastes) of some minerals such as iron, calcium, magnesium, and zinc.

---

asbestos appears to be a cocarcinogen with cigarette smoking in causing lung cancer. One study indicates that asbestos workers who are non-smokers contract lung cancer at a normal rate. Their coworkers of the same age who are cigarette smokers have eight times the possibility of dying of lung cancer, and 92 times the risk of other men who neither smoke nor work with asbestos.

[43]It is difficult to conduct the epidemiological studies necessary to establish definitively the relationship between occupational pollutants and lung diseases. Many variables are involved, and it is not always possible to isolate a single factor for observation. Several diseases have latency periods which can far exceed the worker's employment in a particular place. Individual reluctance to participate in medical studies cuts down an already small target population still further.

[44]The most common of the dust diseases, or pneumoconioses, is silicosis resulting from the inhalation of silicia in its crystalline or amorphous forms. Of the silicates, asbestos is one of the most common causes of serious pulmonary fibrosis. Talc, which is hydrated magnesium silicate, can also produce pulmonary disease after prolonged inhalation. Beryllium, arsenic, lead, potash, and cadium are other metals encountered in factories and mines. In addition, textile fabrics are responsible for the disease known as byssinosis, or "mill fever."

[45]Molecules of substances (wastes) which have a higher concentration inside the body cells then in the bloodstream will diffuse in greater numbers per unit time from the inside out (body cells to blood-stream) until equilibrium is reached.

[46]The 1972 Amendments to the Federal Water Pollution Control Act require that municipal sewage discharges must receive secondary treatment by 1977 and best practical waste treatment technology by 1983.

[47]An increased respiration rate (due to increased muscular activity) aids in regulating the body temperature and in the elimination of wastes.

APPENDIX - LEARNING ACTIVITIES

B-1. Heat as a Form of Energy [10, 9, 8]

Several short activities are best experienced individually and demonstrate the heat resulting from work.

(a) Bend a piece of iron wire back and forth rapidly and feel it to note the rise in temperature.

(b) Draw a large nail out of a board, using a claw hammer, and feel its increased temperature.

(c) Rub the palms of the hands rapidly together.

(d) Pound a piece of lead hard several times and note the temperature rise.

(e) A large, smooth-headed nail can be held in the chuck of a hand drill, pressed head down into a shallow hole in a block of wood and rotated rapidly. The smoke which soon arises is an indication of the temperature rise that results.

B-2. Sunlight Contains Energy [14, 3, 1]

Set a radiometer in direct sunlight and notice how rapidly the vanes rotate. Note the effect of cutting off the sun's rays with a card or piece of paper. This is very direct evidence that sunlight contains energy.

B-3. Sound Energy [17, 14, 2]

Hold a fingernail file or ruler on a desk so that one end projects over the edge. Bend the projecting edge downward and release it suddenly. Notice the vibrations and point out that these vibrations are transmitted to the air which carries them to our ears.

Introduce the concept that pitch depends upon the rate of vibration by varying the length of the portion of the ruler or nail file that projects from the desk. Notice that the shorter this length is the more rapid the vibrations are and the higher the pitch.

B-4. Potential and Kinetic Energy [16, 10, 9]

(a) The "cum-bak" is an interesting child's toy which can be used to illustrate energy concepts. It consists of a cardboard cylinder containing a rubber band stretched between its ends and along its axis. From the center of the rubber band hangs a weight. When the cylinder is rolled, the weight winds up the rubber band and when the initial kinetic energy has been used, the rubber band unwinds, making the toy come back.

Compare its behavior with that of an identical cylinder in which the weight and rubber band have been replaced by an equal weight of lead shot held in place against one end by paraffin.

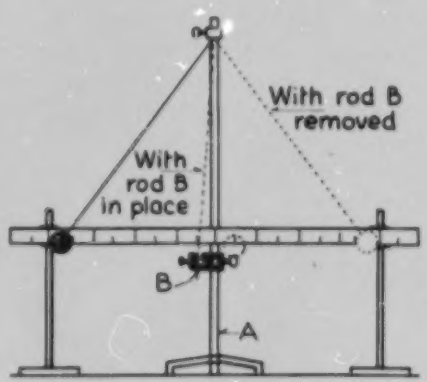
(b) The familiar yo-yo can also be used to illustrate potential-kinetic energy transformation. Be sure to ask the class the nature of the energy at the very bottom of its path to bring out the fact that kinetic energy is not necessarily linear.

(c) A simple pendulum, or weight, bobbing up and down on the end of a coiled spring can be used as a device in which energy is repeatedly transformed.

(d) A double incline can be made of strips of glass and a cylindrical weight allowed to roll back and forth. Glass strips up to 60 centimeters in length and 7-15 centimeters wide are often discarded by glaziers. The slope of the inclines should be very gentle - perhaps 3 centimeters in 120 centimeters. The period of such an arrangement is long enough to permit identification of the various energy states as they occur.

(e) Hang a pendulum from a clamp attached to a vertical support rod, and behind it mount a meter stick which is perfectly horizontal. A tightly stretched horizontal string can be used instead of the meter stick. Show that if a pendulum is started on one side at the level of the meter stick, it will swing as high on the other side, ignoring friction losses. Discuss the change from potential to kinetic, and back to potential energy, making clear their equivalence.

Clamp a horizontal rod B to the pendulum support A, so that it will project and interrupt the motion of the pendulum to make it swing in an arc of smaller radius. If started at the level of the meter stick, the bob will swing to the same height. (See diagram at the right.)



B-5. Forces [17, 13, 8]

At this point the concept of a force as a push or a pull should be established, but its association with motion should be deferred until consideration of the laws of motion. Call attention briefly to various familiar forces: weight, muscular contraction, molecular forces resulting in material strength, and elasticity and friction.

Especially, identify weight as a force and justify the use of weight units in expressing the magnitude of forces. Hang a weight from a coiled spring and show that extensions of the spring caused by other forces can be expressed in weight units since they produce the same effect as weights.

B-6. Calibration of a Scale [22, 21, 20]

(a) Demonstrate the principle of a spring balance scale by using a rubber band for the spring and one marble as the unit of weight. Suspend the scale from the end of a ruler inserted near the top of a stack of books. Slip a strip of cardboard under the ruler so that the end hangs down along one side of the stack of books. Assemble the rubber band balance and adjust the position of the rubber band over the ruler so that the pointer is near the strip of cardboard. Make a mark on the cardboard at this point and indicate it as zero.

Calibrate the scale by dropping marbles into the cardboard box and marking it off into convenient divisions. The pointer should return to zero after the scale has been calibrated and all marbles have been removed from the box.

(b) Weigh some object, such as a piece of rock, on the rubber band scales and note its weight in marbles. Discuss possible means of calibrating the scale in grams.

(c) Weigh common objects found in the classroom in metric units. Spring balances are inexpensive to buy or may be borrowed.

B-7. Nutrients in Milk [6, 4, 11]

An excellent approach to the study of foods is to separate a bottle of milk into its principal nutrients in the following way:

1 Allow a pint bottle of raw milk to stand in the refrigerator until all the cream rises to the top. Pour this off carefully. This cream will contain the fat that was present in the bottle of milk. If cream is allowed to ripen at room temperature for two or three days, it can usually be churned by shaking it in a gravy mixer or even in a bottle. The butter obtained is about four-fifths fat and contains the fat-soluble vitamins.

2 Heat the remainder of the bottle of milk until it is lukewarm. Stir white vinegar or dilute hydrochloric acid, a few drops at a time, into the milk until it curdles. Remove the curds (solid part) from the whey (liquid) by filtration. These curds are a kind of protein called casein. This casein is used commercially to make cheese, buttons, furniture, water paints, plastics, glue, and even some kinds of fabrics.

3 Bring the whey, from which the casein was removed, to a boil. Another kind of protein called milk albumin will now appear in the form of light curds.

4 This can be removed by filtration through filter paper or a piece of paper towel.

5 Evaporate the remaining liquid (filtrate from the milk albumin experiment) in a double boiler or steam bath. As the water is removed, milk sugar forms as a thick deposit in the bottom of the vessel. This milk sugar is sweet to the taste. Besides sugar it contains some minerals and the water soluble vitamins left in the milk sugar. Scrape some of it from the bottom of the vessel and taste it.

6 Arrange the nutrients obtained from the sample of milk in the form of an exhibit. Note that milk contains fats, protein and carbohydrates (sugars) in about the proportion needed for proper nutrition.

B-8. Test for Protein [1, 2, 14]

(a) Tests for proteins involve the use of strong acids and should be carried out as demonstrations by the teacher. The usual test for proteins is to add nitric acid to a sample of food. The sample is then boiled and the acid neutralized by adding ammonia. An orange color indicates the presence of protein.

Take a little white of a boiled egg and place it in a test tube. Add a small amount of nitric acid, enough to cover the egg white. Heat gently, pour off the acid, add ammonia, and note the orange color.

(b) By means of various tests for the nutrients show that lean meat (muscle) consists principally of protein.

Test sugar or a piece of bar candy for protein to show that usually none is present.

Emphasize the fact that our bodies are built mostly of protein and that an adequate amount of protein in the diet is necessary for growth of the muscles and proper physical development.

B-9. Test for Fat [1, 2, 6]

Place a piece of fat on a piece of paper. Warm the paper lightly over a flame. Notice the appearance of the stain as it gradually becomes more and more translucent. When it is held up to a source of light, the light passes through the stain much more easily than it does through the rest of the untreated paper. This is a common test for fat. Most substances that leave a translucent grease stain on paper contain a fat or an oil. Fats that are thick or semisolid usually come from animals. Oils are usually liquid and come from plants.

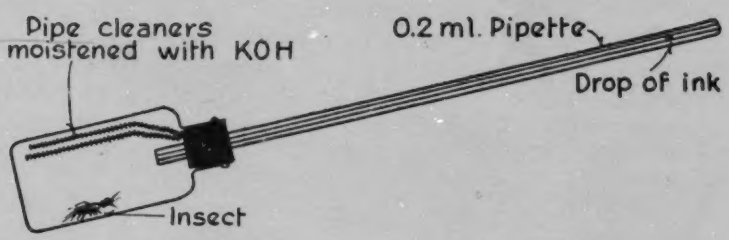
B-10. Measuring the Oxygen Consumption of a Small Animal [13, 12, 7]

If the carbon dioxide produced by a small animal is absorbed, the volume of the surrounding air will be decreased by an amount equal to the oxygen consumed.

Put a rather large insect such as a grasshopper or a cockroach, or several meal worm beetles, in a gas-collecting bottle. Soak several strips of filter paper in a 0.4 percent solution of potassium hydroxide to absorb the carbon dioxide as it is produced. Hold them in place with a piece of wire inserted in the rubber stopper as shown. Seal the stopper with vaseline. Fit a 0.2 ml-pipette into the one-hole rubber stopper.

When the apparatus is closed, touch the top of the pipette to a drop of ink. This will move down the pipette as the oxygen is consumed by the insect (see the diagram).

This activity can also be developed into an individual project by gathering data relative to a number of kinds of insects and other small animals. The effect of temperature can be determined by immersing the bottle in water baths of various temperatures. Note: Pipe cleaners may be used in place of the paper.



B-11. Energy from Oxidizing Food [14, 8, 1]

Surprising amounts of energy are released by the combustion of such food materials as cooking oil, olive oil, melted butter and oleomargarine. Place the fat or oil in an evaporating dish and lay a cotton wick in it so that the end of the wick projects above the edge. When ignited, the flame will last for some time. Place a few drops of water in a spoon and hold it over the flame to boil the water. Point out that an equivalent amount of energy is released whether the food is burned inside or outside the body.

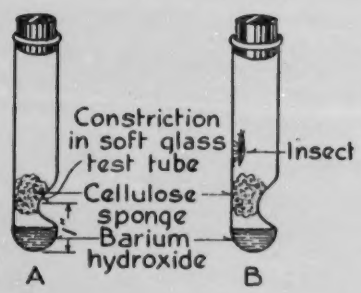
An interesting comparison is the fact that the body releases energy at about the same rate that a 100-watt electric light bulb does. Dramatize this by turning on such a lamp and invite pupils to feel the radiation by holding their hands near it.

B-12. A Rapid Method of Detecting Carbon Dioxide Production [11, 5, 3]

The production of carbon dioxide by living things can be detected in a few minutes by using test tubes modified as shown in the diagram. To do this, heat the side of a soft glass tube about 3 centimeters from the bottom until it is soft, then push it down on a piece of glass rod laid on a sheet of asbestos.

Put 10 drops of filtered barium hydroxide in the bottom of each of two tubes and insert a small piece of cellulose sponge to the constriction of each tube. This will keep the respiring material up out of the barium hydroxide. An insect such as a meal worm beetle should be introduced into one tube, after which both tubes are stoppered. A good precipitate will be produced in the barium hydroxide within 30 minutes, indicating the presence of carbon dioxide. This can be compared with the control tube.

This method may also be used to show the evolution of carbon dioxide in germinating seeds, slices of rippening fruit such as apples and bananas, and yeast cultures. To show the latter, crumble half a cake of yeast into 100 cc of a 10 percent solution of molasses in a flask. The next day, dip a 3-centimeter square filter paper in the yeast culture, blot off any excess liquid, and insert into a tube with 10 drops of barium hydroxide. Control tubes lacking living organisms should be used in all cases.



B-13. Concept of the Calorie of Heat [5, 4, 6]

Put 1,000 cc of water in a large beaker and apply heat very slowly with a Bunsen burner. Holding a centigrade thermometer by the uppermost end, stir the water slowly and constantly taking care not to touch the container. When the temperature goes up 1 degree, 1 calorie has been added for each cubic centimeter of water and a total of 1,000 calories was added to the sample.

By definition, a calorie is the amount of heat necessary to raise the temperature of 1 gram of water 1 degree centigrade. At room temperature a gram of water occupies very nearly 1 cc and since it is easier to measure out a volume sample than to weigh one, we use 1,000 cc rather than the slightly more precise 1,000 grams. It is unwise to heat a sample smaller than 1,000 cc because it might become warmed faster than the thermometer could respond to the temperature change.

B-14. Production of Heat Energy During Respiration [16, 15, 9]

Soak in water overnight enough seeds (kind is unimportant) to half-fill a 500 cc thermos bottle. Soak an equal quantity of the same kind of seeds in 10 percent formalin overnight to kill them. After soaking, drain all the liquid off the seeds and put them on wet cotton in separate 500 cc thermos bottles. Embed a small vial of barium hydroxide solution in each thermos bottle so that the rim of the vial is flush with the top of the seeds. This will absorb carbon dioxide produced and let more air into the seeds.

Insert a laboratory thermometer in each bottle and plug loosely with cotton. Keep a record of the temperature in each bottle over a period of 2 days. At the end of that time open the bottles and examine the barium hydroxide in each.

B-15. Cells - Units of Living Matter [4, 6, 1]

Strip off one or more layers of the fleshy leaf bases from an onion. Remove a piece of the thin skin from the inner surface of one of the leaves. Mount this piece of tissue on a microscope slide. The cellular structure of the onion tissue should show up very clearly when viewed under a microscope.

Add a small amount of dilute iodine solution or eosin to the onion tissue. This will stain the cells and make them stand out more clearly.

B-16. Cytoplasmic Movement in Cells [6, 4, 1]

The cytoplasm in living, active cells is a dynamic moving material. This movement, called cyclosis, may be observed in Elodea leaf cells.

Mount a leaf from the growing tip of a plant, rightside up, in a drop of warm water on a microscope slide. Add a cover slip. Focus on the upper layer of cells near the midrib and look for movement of chloroplasts.

This will require the high power of the microscope.

Movement may be speeded up with a warming light. In reality, the chloroplasts are not moving under their own power, but are being carried along with the movement of the cytoplasm in which they are suspended.

B-17. Human Tissues [4, 1, 2]

Select prepared slides that show clearly the cell structure of human tissues. These must be examined under high power to reveal the cell structure.

It may not be possible to teach all pupils to use a compound microscope skillfully, particularly if the number of the microscopes is limited. Some pupils, however, show special aptitude and learn quickly. The teacher can save time and make more demonstration work possible by giving a few pupils special instruction. These pupils can then take responsibility for handling microscopes when prepared slides are examined under high power.

B-18. Organization of Cells [2, 1, 4]

The organization of cells into tissues, organs, and organ systems to form an organism can be demonstrated very well with a frog. Live frogs are usually available in most localities in the fall and are readily collected on the edges of ponds and swampy places.

(a) The live frog is an independent, functioning organism. Have the pupils observe the activities of a frog in 1 cm or so of water in a battery jar. Such things as breathing movements, reactions to touch, and blinking movements can readily be observed.

(b) This makes a good laboratory lesson in the technique of careful observation and recording. Have the pupil record everything observable about the structure or behavior of the frog during a 15-minute period. At the end of the observation period a discussion will probably reveal many items missed by some groups that others observed. This experience can be used to good advantage to bring out the necessity of great care and completeness in observation and recording.

(c) After a frog has been in water for a day or so, films of epidermis will be seen in the water. These can be picked out and passed to pupils as examples of tissue. The cells making up a tissue can be seen if a bit of the epithelium is spread out in two or three drops of water on a microscope slide. Cover with a cover slip and examine under the low and high powers of the microscope. The structure of the cells can be seen better if dilute methylene blue stain is used on the microscope slide instead of water.

B-19. Coordination of Tissues in Organs (demonstration) [1, 14]

An important concept in the study of complex organisms is that of the coordinated functioning of many different tissues in an organ. This may be demonstrated by means of a dissected chicken leg.

Remove the skin from a complete leg (thigh, drumstick, and foot) of a freshly killed chicken. Separate the individual muscles and tendons to the toes by carefully cutting the connective tissue between them. The muscles of the thigh can be removed completely, leaving only the thigh bone.

If the dissection is done carefully, it will be possible to demonstrate that the contraction of individual muscles of the leg moves specific toes by means of tendon connections to bones. The antagonistic action of muscles can be demonstrated by pulling alternately the tendons on the front and back of the foot. The function of connective tissues in holding tendons in place and the lever action of bones can be demonstrated.

Between the muscles of the leg will be found a tough white cord about the thickness of a string. This is the main nerve supplying motor neuron endings to each muscle cell in the leg.

Emphasize through class discussion the role of nerve impluses in producing muscle contraction as well as controlling the function of the digestive and circulatory systems. The point to be illustrated is the coordination of many cell tissues in producing movement in a given part of the animal body.

B-20. Human Systems [2, 1]

Fold a manikin so that it shows the digestive system only or find a large chart of the digestive system. Trace the course of food through the alimentary canal and develop in general the function of each organ through which the food passes. Note the glands along the alimentary canal, the valves within it, and the location of the appendix.

Fold the manikin so that it shows the circulatory system only. Develop the general concept of the circulation of the blood with emphasis on what happens when the blood flows through the tubes within the lungs, within the kidneys and liver, and those surrounding the intestine. In this study, technical terms should be avoided as far as possible and the discussion should be conducted in terms of the pupils' usual vocabulary.

B-21. Muscles and Bones Move the Body [14, 2, 8]

(a) Ask pupils to find the muscles that move their own fingers. Grasp the forearm with one hand and close and open the fist of the other hand. Move the fingers one by one and find the positions of the muscles that move each finger. Repeat, using the opposite arm and hand.

Find out by direct examination how many bones there are in the upper arm and in the lower arm.

(b) Show X-ray photographs and diagrams of fractured bones of the arm or leg. Explain how a broken bone is set. Give reasons why the application of a cast or splints is necessary while a broken bone heals.

Discuss reasons why a person should not be moved except by a physician when there is a possibility that bones have been fractured in an accident.

B-22. The Skull [14, 2, 1]

Examine whatever animal skulls and mounted skeletons are available in the school collection. Point out that the rounded shape makes the skull very strong and provides protection to the brain. Notice the places where different skull bones are joined together. Find the place where the brain stem leaves the skull.

B-23. The Backbone [14, 2, 1]

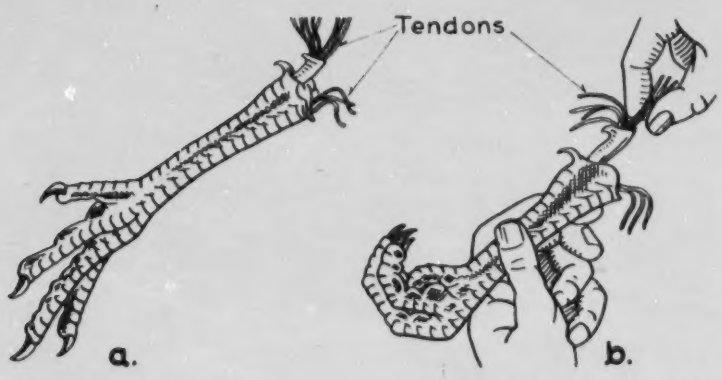
Examine the backbone of an animal skeleton and notice how the shape of the vertebrae provides for flexibility and protection for the spinal cord. Find the openings through which the branch nerves pass. Examine the surfaces of the vertebrae at the points where they touch each other. In the living animal there are pads of cartilage between every two vertebrae.

B-24. Ligaments and Tendons [14, 1, 2]

From a local butcher obtain two items: the joint trimmed from a lamb shoulder and a chicken foot.

Use the lamb joint to show the ligaments that bind the ends of bones firmly together, and the tendons that join muscles and bones.

Slightly trim the severed end of the chicken foot so as to expose the ends of the tendons. Pull on the tendons one by one. Notice that some of them flex the toes and others extend the toes.



B-25. Uses of Levers [17, 8, 7]

(a) Saw off a stick or board so that it is the same height as a heavy desk or table in the classroom. Place another stick about the same length on this. Place the end of this stick under the edge and use it as a lever to lift the desk or table.

Note that in lifting a heavy object with a lever the longer end travels farther than the shorter end. No energy is really gained but the force exerted by the shorter end of the lever is much greater than the force used to move the longer end.

(b) Show that the longer end of a lever travels farther and faster than the shorter end when the fulcrum is not in the center. A baseball bat makes use of this advantage. List other examples of the use of levers and other simple machines to increase speed.

B-26. The Pulley [13, 11, 5]

Complete directions for measuring the ideal and actual mechanical advantages of pulley arrangements are given in laboratory manuals and texts.

Several precautions will make results more accurate.

(a) If the effort, when it acts downward, is to be measured by use of a spring balance, the balance cannot be used accurately in an upside-down position. Instead, attach the free end of the cord to the ring of the balance and pull on the hook so that the balance is upright. This means that the weight of the balance is pulling on the string, even when no force is exerted on its hook; therefore, the balance's weight must be added to all readings as a correction.

(b) The effect of friction can be eliminated by averaging the effort necessary to lift the weight and the effort necessary to lower the weight. The first reading is used in determining the actual mechanical advantage, and the average is used in determining ideal mechanical advantage.

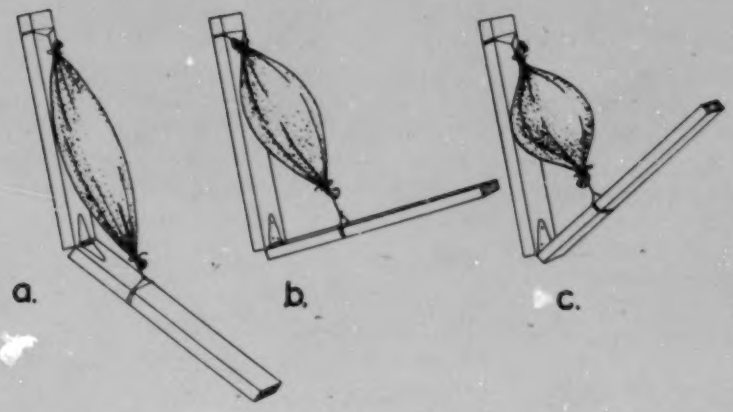
(c) When a moving pulley is used, its weight must be added to the load to determine the total load. Note that this is not the "useful" load.

B-27. Changing Direction of a Force [1, 8]

Find examples of devices used in the schoolroom that change the direction of forces. Door latches, light switches, window shade pulleys, and the pencil shapener are examples.

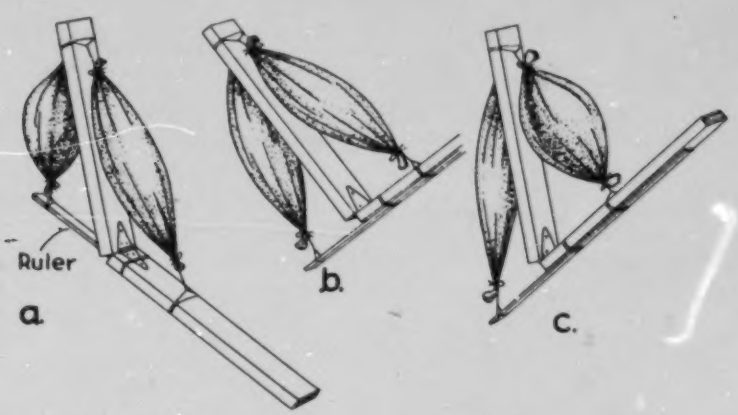
B-28. Bones Act as Levers [18, 19, 21]

(a) Make a model representing the bones and biceps muscle of the arm as shown in diagram I.



Join two pieces of wood two centimeters square and 30 centimeters long with a small strap hinge to represent the bones. For the biceps muscle use a toy balloon. First tie a piece of string tightly around the tip of the closed end of the balloon. Blow a little air into the balloon and tie it shut with another piece of string. Attach the balloon to the "bones" as shown in diagram A. Straighten out the "arm" and the "muscle" will lengthen. Release it and the "muscle" becomes thicker and flexes the arm.

(b) Tie a ruler to the lower part of the model arm so that one end extends a short distance beyond the elbow joint. Attach another balloon containing a small amount of air to represent the triceps muscle.

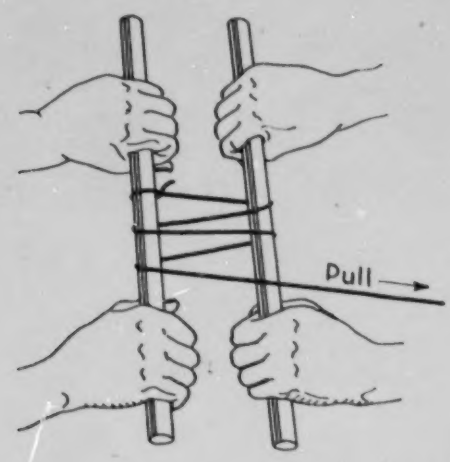


Straighten and flex the model arm and observe the action of the muscles. Call particular attention to the fact that skeletal muscles are always formed in pairs and discuss the reason for this (see diagram I1).

B-29. Pulleys Can Increase a Force [16, 10, 7]

Let each of two pupils grasp a round stick, such as a broomstick, and stand 1 meter apart. Tie a length of clothesline cord to one of the sticks and wrap it several times around both sticks so as to form a combination of pulleys. Ask a third pupil, smaller than the other two and obviously not as strong, to pull on the rope. It will be easy to pull the sticks together despite the efforts of the pupils holding the sticks.

Make a list of devices in which pulley combinations are used to increase forces. Tow cars and power shovels are examples. List other devices and machines used to increase forces.



B-30. Friction [23, 22, 15]

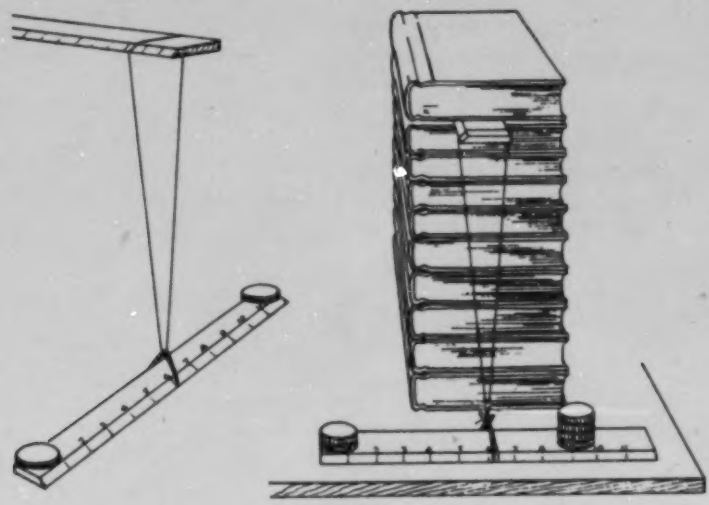
To show that friction depends on the force pressing the surfaces together, drag a block of wood across the desk at a constant speed with a spring balance. Then load the block by placing a weight on it and measure the friction again at this same speed. If this is done for several values of load, a graph of friction as a function of the normal force should be linear.

Two desirable refinements are to slide the wood block along a hardwood board which has been polished to a uniform surface and to exert the force by a weight at the end of a cord passing over a pulley. When the block, once started, slides uniformly on the surface, the weight must be the same as the friction.

B-31. Equilibrium [17, 13, 5]

(a) Suspend a meter stick by loops of cord a short distance above a tabletop, as shown in the diagrams. When the meter stick is in balance, place coins of the same kind in different positions on each side of the fulcrum so that the meter stick balances again. Using the simpler combinations of numbers of coins and distances from the fulcrum, develop an elementary understanding of the principle of moments. For instance,

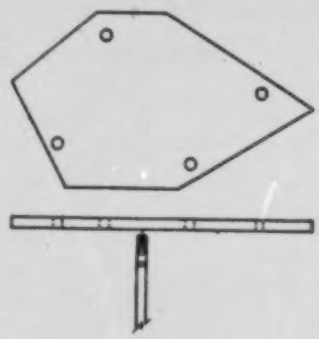
two coins placed at one end of the meter stick will balance four coins placed halfway between the fulcrum and the opposite end.



(b) The beam of a platform balance on which pupils are weighed is really a lever with the fulcrum very close to one end. To show the principle of this type of balance, place a stack of eight or ten coins near the fulcrum of the suspended meter stick used in (a). Slide a single coin along the opposite end of the meter stick until it balances.

B-32. Center of Gravity of an Irregular Object [11, 9, 8]

(a) The center of gravity of an irregular object can be located with the aid of a plumb line. Illustrate this with a board cut in the shape of an irregular polygon. Drill several holes near the edges. When the board hangs from a nail passed through one of these holes, it must take a position with its center of gravity under the nail. A plumb line is hung from the nail and a line drawn on the board directly behind the cord. This is repeated for one or more of the other holes. The resulting lines pass through the center of gravity. This may be shown by driving a nail through and hanging a board in a vertical plane by a loop of cord over each end of the nail. It is seen to be balanced.



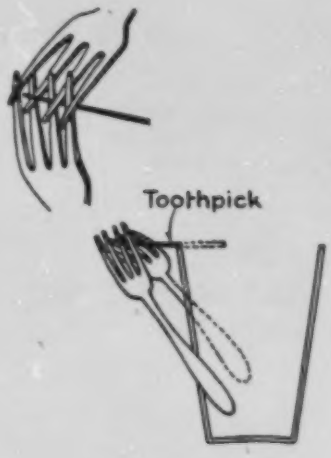
If a thumbtack is inserted at the position of the center of gravity, the board can be balanced on the eraser of a lead pencil.

(b) A demonstration that will interest many pupils is locating the center of gravity of a model airplane. Ask a pupil to bring a large model to class. Support it with the front wheels on one platform balance and the rear wheel or tail skid on another. From these weights and the distance between the points of support, use the law of moments to calculate the position of its center of gravity. Check by hanging it from a cord tied at this computed position.

B-33. Center of Gravity as It Affects Stability [17, 16, 10]

(a) Have a pupil stand with heels against the wall and try to pick up a small object placed on the floor in front of him or her. Notice what happens when this is done without bending the knees.

(b) Interlock the tines of two table forks, insert a toothpick as shown, and balance the combination on the edge of a drinking glass. If the end of the toothpick extending inside the rim of the tumbler is lit, it will burn back exactly to the glass, leaving a precarious but quite stable balanced arrangement. Blow on it gently to make it rock. Discuss the position of the center of gravity of this combination.



B-34. Posture [14, 8, 2]

Find pictures showing good and poor standing and sitting posture. Study the pictures and decide what the characteristics of good posture are.

B-35. Microscopic Structure of Muscle [4, 6, 1]

(a) Striated Muscle Cells. Pupils can make excellent microscopic preparations of striated muscle cells from the leg muscles of frogs. Freshly killed or preserved material may be used. From a block of muscle about one-half centimeter long remove a shred about the size of a heavy thread. Place this in a drop or two of water on a microscope slide and tease it apart into the smallest possible shreds with two dissecting needles. Add a cover slip and examine under the microscope. The light will have to be greatly reduced in order to see the striations.

To see the nuclei of these cells remove the cover slip and add a few drops of dilute methylene blue stain. Allow a few minutes for the stain to penetrate the cells before replacing the cover slip.

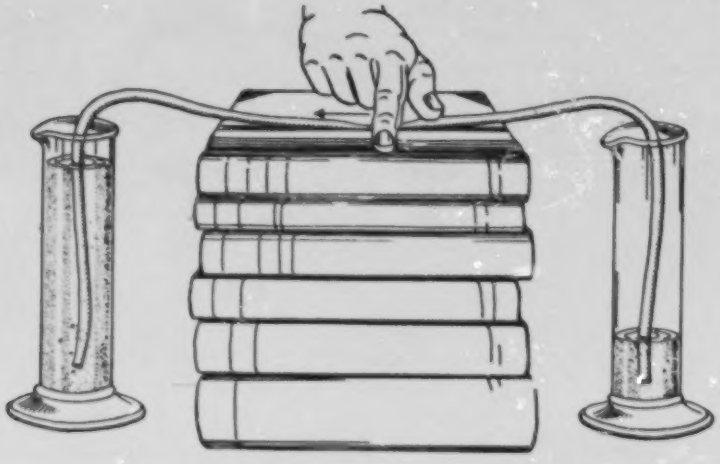
Small pieces of beef or other vertebrate muscle can also be used in the same manner to show the similarity of muscle cells. The muscle cubes can be stored indefinitely in 10 percent formalin.

(b) Smooth Muscle Cells. Bits of muscle tissue from the stomach or intestinal wall of a frog can be handled in the same way as above to show the structure of smooth muscle cells.

B-36. A Model of Peristalsis [18, 19, 22]

A working model illustrating the principle of peristalsis can be set up in a few seconds in the following way:

Fill a drinking glass or similar vessel with water. Insert a piece of gum rubber tubing, draw water into it and allow the water to flow into a second glass through the siphon. The water in both glasses will soon reach the same level.



Now place a few books between the glasses, stroke across the tubing with a finger and keep stroking in one direction to simulate waves of peristalsis. Watch the change of the water level of the two glasses.

B-37. Simple Reflexes in Humans [17, 14, 1]

Pupils can work in pairs to demonstrate many simple reflexes that occur in humans. It should be noted that in each case there is a stimulus and a specific response. Pupils should keep records.

(a) Iris Reflex. One member of the pair should close his or her eyes for 1 minute with a hand over them. At the end of this time, he or she should look at the partner. It will be noted that the pupils, considerably dilated as a result of the time spent in darkness, will quite suddenly contract, as the iris expands in response to the stimulus of light.

(b) Patellar Reflex. Have one member of the pair sit with crossed legs so that one leg swings freely. The other partner should strike smartly just below the kneecap with the edge of the hand. If the stimulus is applied at the proper place, the leg will invariably swing outward.

(c) Sneeze Reflex. With a hair or a piece of thread, tickle the inside of a nostril. Teacher should demonstrate.

(d) Blinking Reflex. Have one pupil hold a piece of clear plastic in front of his or her face. Have the other student throw a loosely wadded ball of paper, aiming at the eye. Blinking will invariably result, even though the student knows that he or she is protected by the piece of clear plastic.

It should be noted that the blinking that one does normally when at rest is also a reflex, the stimulus for which is the sensation of dryness that results from the evaporation of the tear fluid covering the eyeball.

As a result of this series of demonstrations, it should be evident to pupils that reflexes are involuntary, rapid, and often protective in nature.

B-38. Control of Breathing [16, 9, 8]

The rate of breathing is controlled by the effect of blood carbon dioxide content on a control center in the medulla of the brain. If the breath is held for some time, the content of carbon dioxide in lung air is increased. By osmotic equilibrium, this increases the amount of blood carbon dioxide.

Count the number of respirations per minute as you are sitting still. Hold the breath as long as possible. Exhale, and immediately count the number of respirations made during the next minute.

The number of respirations during the minute following holding the breath will be greater than it was during the preceding minute.

B-39. Vision [8, 14, 1]

(a) To demonstrate that man possesses binocular vision, or that two images are combined in normal vision, hold a pencil about 30 centimeters in front of the eyes while looking at a distant object. Then look quickly at the pencil and note the double image of the distant object.

(b) To stress the advantage of binocular vision, have members of the class hold two pencils, one in each hand, at arms length and about 1 meter apart. Have them close one eye and try to bring the rubber tips of the pencils together. Now have them try again using two eyes.

(c) Roll seven or eight sheets of white paper into a hollow roll so that each sheet extends twice around the roll. Slip a rubber band around the roll. Set the roll on the page of a book and press one eye against the top so that no light is admitted at the bottom or the top. It should be impossible at first to read any of the words. If any of the words can be read at first, add a few more sheets of paper to the roll.

With the other eye closed, keep looking through the roll for a minute or two without admitting any light. The print will slowly become legible in the dim light that diffuses through the paper.

As soon as the print can be read clearly, look quickly into a mirror and note the size of the pupils of the eyes. Keep watching the pupils for a minute and see how they change in size as the bright light of the classroom enters the eyes. Each pupil should have the opportunity to perform this experiment.

Suggest some advantages of this ability of the pupils to change in size: contraction of the pupils protects the eyes against very bright light; enlargement helps us to see in very dim light; adjustment of the pupils helps us avoid danger.

B-40. Taste and Smell [16, 10, 9]

Cut a few slices from an apple or pear. Have two pupils test their ability to distinguish between taste impressions and smell impressions.

Blindfold one pupil and have the other place a piece of apple in his or her mouth while a piece of pear is held under the nose. Try the reverse, pear and apple. Then use two pieces of apple and two pieces of pear.

Show that substances such as sugar and salt can be tasted regardless of what odor is being smelled.

Cite examples of situations in which the senses of taste and smell might protect us from harmful or dangerous substances.

B-41. Sense of Hearing [16, 11, 8]

Hearing is an extremely important sense, the value of which is easily demonstrated. Blindfold one student and have him or her hold the end of a finger firmly in one ear. Place four or five other students in different positions about 3 or 4 meters away and click coins together at short intervals so the sound is just audible. Ask the student being tested to point in the direction from which he or she thinks the sound is coming. Let him or her remove the finger and try again; notice how much better the source of the sound can now be located.

B-42. Inheritance of Taste Ability [17, 12, 2]

It is difficult to find many human traits that are inherited and that are not affected by environment. One trait is the ability to taste a harmless substance called phenylthiocarbamide.

Papers that have been soaked in this substance are called PTC papers. Taster papers can be obtained at a very nominal price.

About seven out of 10 persons, on chewing up a bit of the paper, will taste a very bitter substance. Some will taste it as sweet, salt, or sour. The remaining three of 10 will taste nothing but the paper that has been impregnated with the substance.

B-43. Sensitivity of Skin to Touch [17, 13, 12]

Nerve endings sensitive to touch are more abundant in the skin over some parts of the body than others. The density of these nerve endings can be determined by using a pair of dividers such as are used in mechanical drawing.

With careful teacher supervision, pupils should work in pairs on this activity, switching roles when the data has been completed for one person. The subject should be blindfolded so that interpretation of touch will not be influenced by sight.

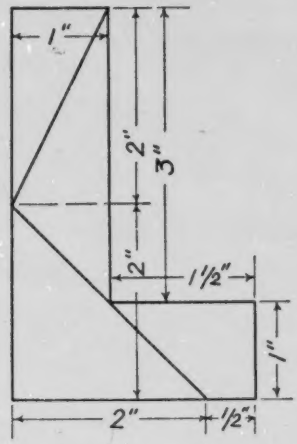
The back of the subject's hand should be touched lightly with the two points of the divider about one-half centimeter apart. Repeat, decreasing the distance until the two points feel as one. The closest distance that the two points can be recognized as two should be recorded. Do this on the skin of other parts of the body, such as the palm of the hand or fingertip. The closer together the points can be distinguished as two points, the closer together are the touch-sensitive nerve endings.

B-44. Trial and Error Learning [17, 15, 12]

(a) An interesting simple exercise illustrating the improvement that comes through repetition of trial-and-error learning follows.

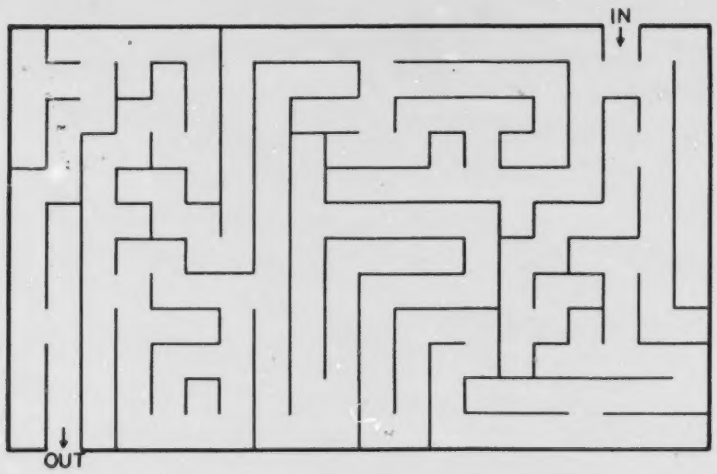
Give each pupil four pieces of cardboard cut as indicated in the diagram on the next page. At a signal, each pupil will begin to arrange the scrambled pieces to form the letter L. Each pupil should keep a record of the time required. As soon as all pupils have completed the task, they should rescramble the pieces and put them together again. When they have completed this ten times, they should make a line graph of their data.

The typical graph will show marked improvement in time in early trials, with improvement tapering off in later trials.



(b) Much learning, both animal and human, is of the trial and error variety. Draw a maze on the chalkboard similar to the one shown in the diagram. Ask a pupil to demonstrate with a pointer the path that the rat must use to get the cheese. The pupil will probably make wrong decisions and be forced to backtrack several times before success is achieved.

When the maze is solved, ask the pupil to run it again and notice the shorter time required. Rats learn to run such mazes without making a single error.



B-45. Learning Under Distraction [17, 13, 8]

Memorization constitutes a type of learning. Duplicate limerick number 1 below and provide each pupil with a copy, face down. On signal, have pupils turn the papers over and memorize the limerick. Allow 2 minutes for this, keeping the room absolutely quiet. At the end of this time, have pupils write the limerick from memory. Score the number of words correct.

Distribute limerick number 2 and repeat the procedure, playing music on a radio or phonograph during the memorization period. Score the number of words correct.

Distribute limerick number 3 and repeat the procedure. This time rap on the desk with a ruler, sound a buzzer or bell, and make other disturbing noises. Score the number of words correct.

Other distracting situations may be set up for the memorization period of limerick number 4.

It is interesting to determine the class average of correct words for each situation. In a discussion following this activity the desirability of quiet conditions for study can be brought out.

Limerick 1

There was a young lady, whose nose
Continually prospers and grows.
  When it grew out of sight
  She exclaimed in a fright
"Oh! Farewell to the end of my nose!"

Limerick 2

There was a young lady named Bright,
Who traveled much faster than light.
  She started one day
  In a relative way
And returned on the previous night.

Limerick 3

There was a young lady of Norway
Who casually sat in a doorway;
  When the door squeezed her flat
  She exclaimed, "What of that?"
This courageous young lady of Norway.

Limerick 4

There was a young lady of Niger
Who smiled as she rode on a tiger;
  They returned from the ride
  With the lady inside,
And the smile on the face of the tiger.

B-46. Importance of Understanding to Learning [17, 12, 8]

(a) Provide each pupil with a copy of the three lists of words printed below. Instruct them to read each list 3 times, cover it, and write the words in the list on a separate sheet of paper in the correct order.

APPENDIX - LEARNING ACTIVITIES

Pupils should score their own papers, allowing one credit for each correct item.

List A	List B	List C
Zod	table	ecology
Gid	vegetable	deals
Nur	short	with
Deh	before	living
Hif	write	things
Kep	school	and
Joz	mother	their
Zub	time	relationships
Kol	walk	to
Woj	morning	environment

Since the items in list A are all nonsense syllables, scores will be poorest here. The letter combinations in list B are all familiar words. Scores will be better here, but many points will be deducted because of improper order. The third list, being a sentence, has something to tie the words in order, and scores will be highest here. This should emphasize the importance of being sure pupils really understand material presented in class before being asked to study.

(b) As a variation of the above, and to emphasize the same facts, try the following. On the chalkboard, list the words in the following two columns. Cover the list so the pupils cannot see them.

Column A	Column B
no	leaped
in	in
mistake	the
water	pool
what	on
there	a
leaped	dare
pool	what
a	a
the	mistake
a	no
dare	water
on	there

Uncover the words of column A and direct pupils to memorize the list of words as they appear. Have pupils raise their hands when they have memorized the list and record the time.

After this has progressed for 5 minutes, or until all have memorized the list, whichever is less, uncover the words in column B. Direct the pupils to memorize the words in this list which, of course, are the same

words but in an order that makes sense. Memorization will take place in much less time, since column B makes sense and column A is meaningless.

B-47. Uniqueness of the Individual [16, 10, 9]

Each individual human is different from every other human because each has had a different combination of experiences. This causes each of us to have different reactions to the same situation.

Read the following list of words to the members of the class, or have the list duplicated. Ask each pupil to write after the word the first word that comes to mind. It is unlikely that two pupils will have the same list of response words.

table	country	family	school
religion	books	snake	mirror
hat	house	desk	shade
dog	shoe	lemon	diamonds

B-48. Making Judgments [14, 17, 8]

For pupils addicted to television, an interesting homework assignment might be the rating of their favorite commercials according to a scale such as the following:

F — Fair and reasonable claims for the product
E — Extravagant claims which promise more than it is reasonable to expect of the product
M — Misleading claims, based upon testimonials of famous athletes or "independent experts"
D — Dangerous claims or appeals, such as advertising that encourages self-medication

B-49. A Reflex [2, 1]

Blindfold two or three pupils and tell them that their pupillary reflexes are to be observed at the end of two minutes. In advance of the blindfolding place a few metal rods or large nails in a glass of hot water. Touch each of the blindfolded pupils with the warmed rod on the neck, ear, or hand and note his reaction. Use this as a springboard for developing an elementary concept of the reflex arc.

B-50. Conditioning [19, 20, 22]

(a) Review descriptions of the experiments with dogs carried on by the scientist Pavlov. Make a list of examples of conditioned reflex behavior that have been developed in dogs. Have pupils make a similar list for themselves or someone they know.

(b) Even fish have the ability to learn. If a feeding ring is used in the classroom aquarium, notice the reactions of the fish when the ring is placed on the surface of the water.

If the fish are not accustomed to a feeding ring, begin using one. Keep a record of the reactions of the fish on feeding days and determine how long it takes for the fish to associate the ring with feeding time.

B-51. The Nature of a Habit Response [16, 10, 9]

(a) After long practice, habit responses tend to become unconscious and uncontrolled. As a result of long and constant repetition they have become automatic. This can be demonstrated with a simple exercise.

Dictate the following passage rapidly after instructing pupils not to dot the i's or cross the t's.

"Terrible Tabby is a tiny kitten. Indians often trapped rabbits. The thirteenth fairy was wicked. The little letters on the sign in the window were painted pink. The third tree to the right is a fir. The rain drifted earthward from the trees. The noises of the night filled the air. Time and tide wait for no man."

The habit of dotting i's and crossing t's is so deeply ingrained that most pupils will be unable to control it.

(b) Demonstrate the formation of a habit by using the principle of repetition. Ask pupils to write their names with the hand they do not ordinarily use in writing, which in most cases will be the left hand. The first few trials will usually show little improvement.

At the beginning of the period on several successive days ask pupils to write their names five times with the unaccustomed hand. Within a surprisingly short time most pupils will be able to write their names with either hand.

B-52. Animal and Human Behavior [14, 2, 1]

(a) As a written exercise, ask each pupil to think of a particular animal the he or she has observed closely and then to list at least five specific things he or she has noticed about the animal's behavior. Collect the pupils' papers and use them to develop, through directed discussion, some of the more important elementary understandings regarding animal behavior.

For example, a pupil might select a dog he or she knows, though not necessarily his own pet. Among the observations might be listed:

- He wags his tail when spoken to.
- He comes only when certain people call him.
- He knows he is not allowed to cross the street.
- He barks at the milkman but not at other people.

Ask pupils to suggest possible explanations of each of the types of behavior observed.

(b) Call attention to the fact that humans learn to respond to certain signs and signals just as dogs do. Hearing the fire gong sets off one kind of behavior. A basketball referee's whistle causes another. The sharp blast of an automobile horn heard close by results in still different behavior. The reaction in each case depends upon previous experience and training.

Ask each pupil to choose a classmate for secret observation and to record his or her responses to several situations as indicated below:

SITUATION	TYPE OF BEHAVIOR
Broke the lead in his pencil.	Sharpened his pencil.
Heard noise in rear of room.	Looked around to see what it was.
Was asked a question he could not answer.	Tried to look thoughtful.

B-53. Endocrine Glands [2, 1]

On an anatomical model or physiology chart locate the principal glands of internal secretion. Point out that chemical substances secreted by these glands are carried by the blood and produce changes in organs throughout the body. Cite examples of the influence of various hormones on behavior.

B-54. Human Digestive System [2, 1]

A torso model is a most effective and efficient device for teaching the location, size, and appearance of the parts of the alimentary canal. Next best are the inexpensive paper manikins listed in scientific supplies catalogs, which show the organs in two dimensions. Either of these devices represents an interesting approach to the study of the digestive system.

B-55. Effect of Particle Size on Rate of Digestion (demonstration) [17, 14, 10]

Hard boil an egg and remove the white. Separate this into two portions, equal by weight. Chop one portion finely and the other in coarse pieces. Place both portions in tubes containing equal parts of 1 percent pepsin solution and 1 percent hydrochloric acid (artificial gastric juice). Leave in a warm place overnight. The next day pour the artificial gastric juice off each and dry the remaining egg white on paper towels. Weigh each portion.

The egg white in smaller pieces has a much larger surface area exposed to enzyme activity than that in large chunks. There will be more egg white left in the portion left in large pieces, indicating less "digestion" than in the portion chopped finely. Relate this information to the advisability of chewing food thoroughly.

B-56. Solutions [14, 2, 6]

A solution is a homogeneous mixture of two or more substances, the composition of which may be varied. The dissolving medium is the solvent and the substance dissolved is the solute.

Prepare two containers of water, of suitable size, which can readily be seen. To the first add a spoonful of clean sand, sulfur, or a granulated metal, and stir. To the second add a spoonful of a colorful, powdered compound such as copper nitrate, ammonium dichromate, or nickel sulfate, and stir. Contrast the contents of the two containers. Discuss the "disappearance" of the colored salt, the "appearance" of color (chromogens) in every drop of the second container, the homogeneous distribution of the color, and the permanent (nonsettling) character of the mixture. Compare the solution with a spoonful of the dry salt in a beaker and encourage the pupils to explain what must have taken place among the molecules of solvent and solute to account for the difference.

To assist the discussion make a solution in "slow-motion" as follows. By means of a burning candle, place a daub of wax on the bottom (convex) surface of a watchglass or petri dish, and push into the wax a crystal of potassium permanganate. Float the dish on a large cylinder filled to the brim with water. Observe the process of dissolving.

B-57. Rate of Solution [23, 22, 20]

The rate at which a solute dissolves is influenced by such factors as surface area, agitation, and temperature. Demonstrate the effect of each to the class.

(a) Surface Area. Weigh a large crystal of copper sulfate, chrome alum, rock candy, or similar material. With a mortar and pestle, finely pulverize an equal weight of the same material. Add the two portions to separate beakers containing equal amounts of water. Stir the contents of the two beakers at equal rates. Since all other conditions are equal, the degree of subdivision must be responsible for the different quantity dissolving per unit of time.

Display an apple, orange, or potato and discuss the amount of exposed surface. Make several more cuts to show that the greater the degree of subdivision, the larger the surface exposed to the environment.

(b) Agitation. Pulverize a small quantity of a colorful soluble salt such as copper sulfate. Divide this into two equal portions by weight. Add one portion to a beaker of still water. Add the other to a beaker set up for rapid agitation of the contents with a magnetic stirrer, electric "blender," or by hand. Show that in the first case, a heavy, locally saturated solution soon surrounds the crystals if left undisturbed, while in the second case, agitation constantly brings unsaturated solvent in contact with the crystal surfaces. Repeat, but, instead of agitating in the second beaker, tie the salt in an empty tea bag and suspend just under the surface. The heavier saturated solution can now flow downward, and fresh solvent moves constantly into the bag, effecting a faster rate of dissolving. Indicate that the process of going into solution occurs only on the surface of the solid.

(c) Temperature. Select two small crystals of potassium permanganate of of about equal size. Prepare two beakers containing equal amounts of water, one at room temperature or colder, the other at about 80°C. Drop a crystal in each, and observe the rates of dissolving. Relate this to the increased molecular activity at the surface of the crystal and increase in the rates of diffusion. Raise the question of the effect of convectional currents in the solvent on the rate of dissolving.

B-58. Effect of Temperature on the Solubility of Solids [23, 22, 19]

In general, solids are more soluble at higher temperatures.

(a) To 100 gm of potassium nitrate in a beaker, add 100 ml of distilled water. Stir until no further solution seems to take place. Observe the temperature. Determine the weight of the salt now in solution by referring to the solubility tables. Predict how hot the solution would have to be to dissolve all the salt. While stirring frequently, heat the solution to the selected temperature. Place a little of the warm solution in a petri dish and allow it to cool on the stage of the overhead projector.

(b) Shake a small amount of lead chloride with cold water in a test tube. Heat the water, boiling if necessary, until the salt dissolves. Lower the temperature by holding the tube under the cold water tap.

(c) Some salts become less soluble as the temperature rises. Dissolve 0.2 gm of pure calcium hydroxide (be sure it has not converted to $CaCO_3$) in 200 ml of water and heat to boiling, or saturate 100 ml of ice water (0°C) with 19 gm of ferric sulfate and raise to boiling.

Have the pupils explain the results by reference to the solubility of these substances as listed in a handbook. Also try calcium acetate and calcium chromate.

B-59. Digestion of Starch by Saliva (demonstration) [4, 6, 1]

(a) Put 1 gm of starch in 1,000 cc of hot water. Heat and stir until an opalescent paste results. Fill two tubes with the paste and hold against the light so that the opalescence can be observed.

Add a few drops of saliva to one tube and an equal quantity of water to the other. Shake both tubes thoroughly. After a few minutes, hold both up to the light. The one with the saliva will shortly become quite clear due to the digestion of the saliva to dextrin and maltose, a reducing sugar.

Add a few drops of iodine to some of the material from each tube. The characteristic black color of iodine and starch may be seen only in the tube lacking the saliva.

Test some of the material from each tube with Benedict's solution. Sugars will be found present only in the tube containing the saliva.

(b) Sprinkle a few grains of starch in a drop of water on a microscope slide. Add a drop or two or Lugol's iodine solution, which will color the starch grains black in the characteristic indication of starch.

Add a bit of saliva to the mixture of starch, water, and iodine on the microscope slide. In a matter of a half hour or so, the grains of starch should lose their color and disappear as they are changed to sugar and dissolve in the liquid. The presence of the iodine does not seem to interfere with the action of the saliva enzyme.

B-60. Necessity of Digestion [17, 14, 5]

(a) Starch is insoluble in water, whereas sugar is soluble. To show this, mix 5 gm of starch in 100 cc of water and 5 gm of dextrose (not sucrose) in another 100 cc of water, stirring well. Put a small amount of the starch mixture in a test tube with iodine to confirm the fact that it is starch. Confirm the dextrose mixture with Benedict's solution and heat.

Set up two funnels, and filter some of each mixture into separate flasks. Test some of each filtrate for the presence of the original material in the mixture.

The starch filtrate should be negative for starch, since the mixture is a suspension rather than a solution, and will not pass through the filter paper. The sugar, being in solution, should be present in the filtrate in as great a concentration as it was originally.

Most foods, like starch, are insoluble and cannot enter a cell through its membrane any more than they can pass through the filter paper. The chemical process by which foods are changed into soluble materials is digestion.

(b) Test different kinds of soda crackers for both starch and sugar and select a kind that shows starch only. Ask a pupil to chew a piece and to place the cracker-saliva mixture in a test tube. The sugar test should show that some of the starch has been changed to sugar.

B-61. Digestion in Green Plants [1, 11]

Digestion must take place in green plants as well as in animals. Foods are stored in the plant body in the form of insoluble starches and fats. They must be digested so that these nutrients can be dissolved in plant fluids for transportation and diffusion into cells where they will be utilized.

(a) Digestion in Germinating Seeds. Soak a number of bean seeds overnight and plant them in damp sawdust or vermiculite to germinate. When the sprouts are several centimeters long, but before they have developed chlorophyll, remove a number of seedlings with their attached seeds from the germinating bed. Grind them with a little water in a mortar. Test the ground material for the presence of both starch and simple sugar.

Grind several dry bean seeds in the mortar and test them for the presence of both starch and sugar. Compare these results with those obtained using germinating seeds.

(b) Petri Plate Demonstration. Most ordinary grades of white paper contain a sizing of starch which can be utilized in a convenient, simple demonstration of starch digestion by germinating seeds. For this demonstration select a white paper that shows a positive starch test when Lugol's iodine solution is applied.

Soak some grains of wheat or rye overnight and germinate them on moist filter paper in a petri dish. When they have developed 2 centimeters or more in length, split a seed lenghtwise while still attached to the sprout. Lay the seedlings with the cut edge of the seed in contact with a piece of moist white paper in a petri plate. Cover and set aside for several hours or a day.

Enzymes secreted by the germinating seed will diffuse into the paper and digest the starch of the paper. This can be shown by a wash of Lugol's iodine solution over the paper.

B-62. Gastric Digestion of Protein (demonstration) [11, 7, 6]

Artificial gastric juice can be made from equal parts of a 1 percent solution of pepsin and 1 percent hydrochloric acid. Egg white is a fairly pure source of protein, the nutrient whose digestion is started in the stomach.

Fill a 16-centimeter length of 2-mm or 3-mm glass tubing with raw egg white by drawing it up into the tube with your mouth. Coagulate the egg white in the tube by holding it in a beaker of boiling water. With a file, cut the tube containing the coagulated egg white into four pieces of approximately equal length. Put the tubes in bottles containing the following materials so that both ends of the tubes are covered.

Bottle 1. Equal parts of 1 percent pepsin solution and 1 percent hydrochloric acid (artificial gastric juice)

Bottle 2. One percent pepsin solution

Bottle 3. One percent hydrochloric acid

Bottle 4. Water

Stopper all bottles and leave in a warm place overnight. There will be considerable egg white gone from each end of the tube in artificial gastric juice, indicating that the egg white has been changed to some soluble substance. The fact that pepsin functions best in an acid medium will be indicated by a much smaller amount of digestion in the tube in the pepsin alone. The fact that it is the pepsin and not the acid which functions as the enzyme will be indicated by the lack of any digestion in the tube in the acid alone. The tube in the bottle of water serves as an additional control.

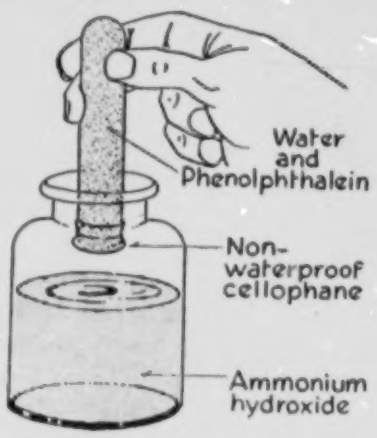
B-63. Structure of Villus (demonstration) [2, 1]

Many fine and relatively inexpensive plaster and vinyl models of the villi are available from most biological supply houses.

B-64. Diffusion Through a Membrane [18, 20, 21]

Living cell membranes are something like screens in that they allow small individual molecules to diffuse through them while stopping large molecules or clumps of molecules, as in a suspension. As such, they are described as semipermeable membranes. Several demonstrations are available to illustrate this behavior of membranes as molecular sieves. Soluble molecules of salt, dextrose and ammonia are easy to detect, as are the insoluble molecules of starch. Therefore, they are the ones chosen for use in these demonstrations.

(a) Diffusion of Gas Molecules. Fill a test tube with distilled water to which 10 cc of a solution of phenolphthalein have been added, and fasten a piece of nonwaterproof cellophane over the open end of the tube. This may be held in place with a piece of string or a rubber-band. Invert the tube into the open mouth of a bottle of ammonium hydroxide, being sure that there is an airspace as shown in the diagram. As the ammonia molecules diffuse through the cellophane, they will dissolve in the water in the test tube, forming an alkali and causing a color change in the phenolpthalein. It should be noted that the color change is due to an increase in alkalinity and is not a specific test for the presence of ammonia.



(b) Diffusion of Iodine Molecules in Solution. Fill a test tube with 1 percent starch suspension, fasten nonwaterproof cellophane over the open end with a rubber band, and invert the tube in a beaker containing Lugol's iodine solution. Fill another test tube with Lugol's iodine solution, fasten cellophane over the open end of the tube with a rubber band, and invert in a beaker containing a 1 percent starch suspension.

In a short time the starch in the test tube and beaker should turn black as the iodine molecules diffuse through the cellophane into the starch. The iodine will remain its original color, since none of the starch molecules can diffuse through the membrane. The iodine is in solution; the starch is in suspension.

(c) Diffusion of Sugar and Water Molecules through a Membrane. Obtain some cellulose tubing, such as is used in making skinless hot dogs, from a local packing house.

Wet a length of tubing about 30 centimeters long and close one end by tying a knot in it. Pour corn syrup into the tubing. Squeeze out all air and close the other end by tying a knot in it. Pull both knots tight so that there are no leaks and rinse off any corn syrup that may have gotten on the outside.

Weigh the tube and its contents and put it in a beaker of water. Several hours or a day later reweigh the tube and its contents. Remember that the molecules in the beaker are 100 percent water, while the sugar molecules in solution inside the tube reduce the water concentration to a point considerably below 100 percent. This means that water molecules would be expected to diffuse from the beaker into the sugar solution, increasing the weight of the tubing.

Likewise, the concentration of sugar molecules is greater inside the tube than outside. They would then be expected to diffuse out of the tube, eventually bringing about an equilibrium of concentration. Test some of the water in the beaker with Benedict's solution to see if this has been the case.

Many modifications can be tested with this apparatus and interpretation of the results developed. The tube may be filled with water and put in a solution of corn syrup. Starch suspension may be substituted for corn syrup both inside and outside the tube. Pupils may suggest many other possible combinations of materials to be tried.

(d) Rapid Diffusion Demonstration. Tie a knot in the lower end of a 15-centimeter length of cellulose tubing and fill it with corn syrup as in (c) above. Instead of tying the upper end of the tubing, slip it over the lower end of a 1-ml pipette. A rubber band made by cutting off the end of a small rubber tubing can be rolled down the pipette and slipped over the cellulose tubing to hold it in place on the pipette. Hang the pipette from a ringstand so that all the cellulose tubing is below the surface of water in a beaker.

Within a few minutes the liquid level in the pipette will begin to rise due to osmosis or the diffusion of water molecules into the tube because of their greater concentration outside the centimeter tube. A rise of 1 cm every 5 minutes is not uncommon.

B-65. Diffusion of Materials into a Cell [22, 19, 18]

Models are often useful in developing concepts of structure. Prepare some colorless gelatin and pour it into a cellophane or plastic bag placed in a transparent plastic refrigerator box. As the gelatin begins to harden, whip it a little in the bag to make it somewhat frothy. Embed a marble near the center to represent the nucleus. Green peas can be added to represent chloroplasts. Tie the bag and place the lid on the box.

The model can be made to represent an animal cell by omitting the chloroplasts and removing the bag from the box (cell wall).

One of the advantages of such a model is that the transparent nature of the materials used enables the student to visualize a cell in three dimensions instead of the two-dimensional picture afforded by microscope slides.

The diffusion of materials such as water and digested food into a cell can be demonstrated by adding a gram or two of corn starch to the gelatin while it is being dissolved. After the cell is completed, place the plastic bag and its contents into a beaker containing Lugol's iodine solution.

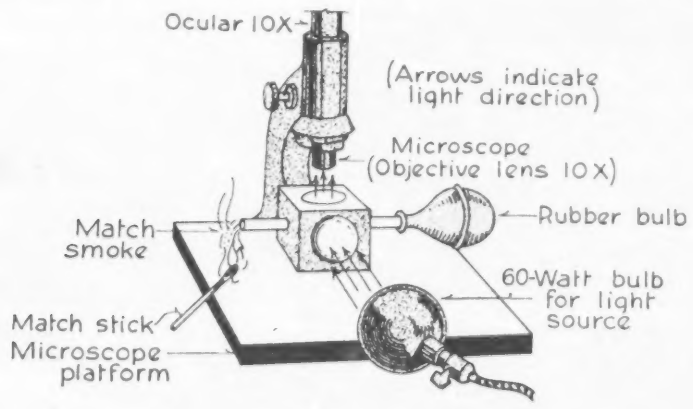
The diffusion of the dissolved iodine molecules into the cell will be indicated by the appearance of the characteristic black color. The starch molecules, being in suspension rather than in solution, do not diffuse through the plastic. This is indicated by the fact that the iodine outside the cell does not become black in color.

B-66. Kinetic Molecular Theory [18, 4, 1]

(a) Exhibit clear glass bottles of iodine crystals and liquid bromine to show the vapor phase present in each case. Place stoppered bottles containing water concentrated with ammonia and concentrated hydrochloric acid, side by side and discuss the presence of vapor above these liquids. Remove the stoppers from the ammonia and acid to confirm the presence of invisible vapors by the formation of ammonium chloride smoke.

(b) A microscope may be used to observe the Brownian movement as shown in the diagram. For best results use only a little smoke and replenish the supply every few minutes. If a totally dark room and a good arc light are available, projection of the motion may be successful if the projector is kept near a good beaded screen. Try using carmine dye powder in pure methanol placed on a concave microscope slide.

Simulated Brownian motion can be observed by scattering powdered camphor crystals on water in a petri dish placed on the overhead projector.



B-67. Diffusion of Gases [23, 22, 19]

The diffusion of gas molecules can be shown by a demonstration which is assembled at the beginning of a class and observed every now and then during the period. Use a 1-meter length of large diameter (about 1.5 cm) glass tubing in a horizontal position. Wet a wadded filter paper with ammonia and place in one end; place in the other end a piece of filter paper wet with hydrochloric acid. Cork both ends. With a tube 1 meter long, reaction becomes apparent in about 10 minutes and the ammonium chloride deposit between the ends is quite dense in half an hour. This ring is fairly well localized nearer the acid than the ammonium hydroxide, illustrating the greater diffusion rate of the less massive molecules. The inclination of the ring is caused by the fact that the ammonia molecule is lighter than air, the hydrogen chloride molecule more dense.

B-68. Solution Dilution [14, 7, 5]

Dissolve 1 gm of potassium permanganate or some intensely colored dye in 1 liter of water. Stir until the solution is uniformly colored. Remove 1 ml of the solution and mix it with another liter of clear water. The dilution is now one part of dye per million parts water. Compare this dilute solution with clear water and note whether any color can still be observed. If so, many particles of the original dye are still present and there must have been a million times this many in the original sample of dye.

The dye fluorescein which is used to trace the course of underground streams can be detected when diluted as much as one part in 10 million.

B-69. Diffusion Demonstration Using Plant Materials [16, 9, 3]

Several simple demonstrations making use of plant structures illustrate the fact that the diffusion of molecules through a membrane always results in movement from greater to lesser concentrations.

(a) Carrot Osometer. Select a carrot which is more than 2.5 centimeters in diameter and 15 centimeters long. With a cork borer or a drill, press out a 1-centimeter or larger hole into the carrot from the top, 5 centimeters deep. After removing the lower tip, fasten the carrot in a clamp on a ringstand to hold it upright in a battery jar of water.

Fill the cavity in the carrot with molasses or corn syrup and insert a one-hold rubber stopper containing a length of 3-mm or 4-mm glass tubing 60 centimeters long. The stopper must fit the opening in the carrot tightly so that it is watertight. If there is any doubt about this, it can be sealed with modeling clay.

Set the apparatus aside until the next day. There will be a rise of the liquid level in the glass tube due to the entrance of water molecules. If ink is added to the material put into the carrot cavity, the rise in the glass tube will be more easily seen from a distance.

Other vegetables such as turnips, parsnips, and potatoes may be used for this demonstration. A variety is assured if each pupil brings a vegetable and sets up an individual apparatus.

(b) Osmosis into and out of Plant Tissues. Cut cylinders of a raw potato with a cork borer and cut into 3-centimeter lengths. Place some in plain water, some in a 1 percent salt solution, and some in a 10 percent salt solution.

After several hours or a day, remove the potato cylinders from the liquid. Check the diameter of each against the original by fitting them into the cork borer used to make the cylinder.

It will be expected that the cylinders placed in plain water will be larger due to the passage of water into the plant tissues. Those placed in the 1 percent salt solution will be essentially the same size, since the percentage of water in a plant cell is about 99 percent, the same as in the 1 percent salt solution. Those placed in the 10 percent salt solution should be somewhat smaller since the percentage of water in the 10 percent salt solution is considerably less than the percentage of water in plant cells.

Other vegetables and fruits such as apples and pears can also be used. This is another excellent individual exercise with each pupil bringing his or her own vegetable material and mixing individual salt solutions.

(c) Plasmolysis in Plant Cells. The removal of water from plant cells by osmosis is known as plasmolysis. Plasmolysis occurs in the potato cylinders placed in the 10 percent salt solution in (b) above. Plasmolysis in individual cells can be shown very clearly by using a leaf of Elodea and a 5 percent or 10 percent salt solution.

Place a single leaf of Elodea on a microscope slide with a drop or two of water. Add a cover slip and examine under the low and high power of the microscope. It will be noted that the cell membrane is tight against the inner margin of the cell wall and that the chloroplasts are distributed throughout the cell.

Remove the cover slip and dry the leaf with a blotter. Cover the leaf with several drops of a 5 percent or 10 percent salt solution and, after several minutes to allow the movement of water molecules to take place, replace the cover slip. Examine under the low and high power of the microscope.

Each cell will appear to have a green football inside it, with a colorless space between the football and the cell wall. This is caused by the movement of water molecules out of the protoplasm to the surrounding medium where it is only 95 or 90 percent as compared with the 99 percent water found in the solutions of protoplasm. The porous cell wall, being rigid, does not change size. The condition is much like sticking a needle through a cardboard box into an inflated balloon inside the box. The balloon, losing air, will collapse while the surrounding box retains its original shape.

The removal of water by plasmolysis reduces the water content of protoplasm to the point where life processes no longer can proceed, and the cell soon dies. This is the basis of the use of salt to kill weeds. The resulting plasmolysis kills the cells of the weed roots, resulting in the early death of the entire plant.

B-70. Difference in Permeability of Living and Dead Cell Membranes [10, 9, 8]

In the cells of the beet, the red color is due to the presence of the pigment anthocyanin dissolved in the cell sap.

From a beet, cut two strips of equal size, about 3 centimeters long and a half of a centimeter wide and thick. Wash each in water to remove the pigment that has escaped from the cut cells.

Place the strips of beet in separate test tubes and cover each with water, filling the tubes about one-third full. Heat one of these tubes until the water boils for a minute, leaving the second as a control.

Examine the tubes at the end of a half-hour. It will be found that on being killed, the membranes of the cells in the tube that was boiled have become more permeable. Much of the red pigment will diffuse through the dead cell membranes into the surrounding water, coloring it red. The water in the control tube will remain colorless, since the pigment cannot diffuse through the cell membranes.

B-71. Study of Heart Structure [1, 2,]

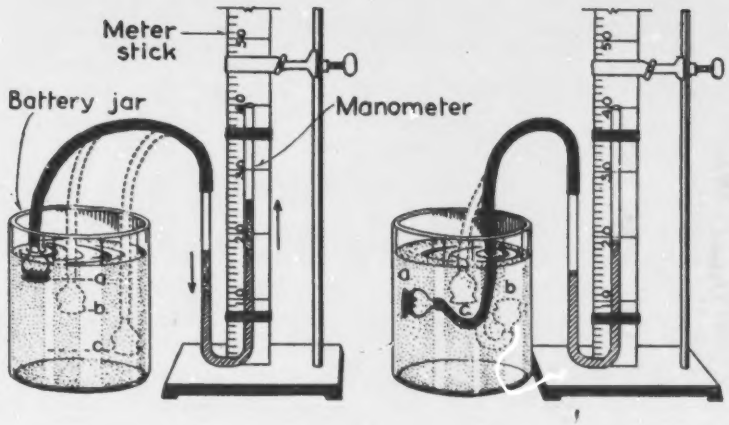
(a) Models of the heart may be used effectively in developing an understanding of the structure of the heart.

(b) Blood is forced through the circulatory systems of vertebrate animals by a heart of two chambers (fish), three chambers (amphibians and reptiles), or four chambers (birds and mammals). Obtain a specimen heart of each class of vertebrate. A butcher shop or supermarket will be able to supply hearts of fish, birds, and mammals.

Bisect each heart to expose the chambers and valves between chambers. Mount dissected specimens on glass plates in jars of formalin.

B-72. Pressure Within a Liquid [5, 4, 3]

The principle that water pressure depends upon its depth and that the pressure at any depth is the same in all directions can be demonstrated with the apparatus shown in the diagram on the following page.



B-73. Heart Sounds [2, 1]

Most pupils have never heard heart sounds. Many high school biology laboratories have stethoscopes or they may be purchased from supply houses. However, pupils can fabricate a stethoscope from a small glass funnel, a glass "T" or "Y" tube, and some rubber tubing. Slip a piece of rubber tubing 7 to 10 centimeters long over the tip of the funnel. Insert the "T" or "Y" tube into the other end of the short piece of rubber tubing and attach longer pieces of tubing to both arms of the "T" or "Y" tube. By placing the funnel firmly against the chest over the heart and the ends of the tubing in the ears, heart sounds can be heard.

The familiar "lub-dub" sounds that pupils will hear represent the sound of valves closing. The first of the pair, or "lub," represents the closing of the bicuspid and tricuspid valves between the atria and ventricles as the ventricle contracts. The closing of these valves prevents the backward flow of blood into the atria and insures that it proceeds out the arteries. The second, or "dub," represents the closing of the semilunar valves at the bases of the aorta and pulmonary artery as the ventricle expands to receive more blood.

B-74. Locating Valves in Veins [2, 1]

The prominent veins in the forearm are useful in pointing out to pupils the location of valves in veins. Each pupil can do this simple procedure himself.

Let the arm hang at the side and pump the fist open and closed to make the veins stand out. This muscle activity squeezes the veins within the arm, forcing a greater part of the blood in the arm to return to the heart through the superficial veins.

With the arm still at the side and the veins prominent, make a tight fist. Place a finger on a prominent vein near the elbow and with some pressure slide it toward the wrist, holding it near the wrist. This will force the blood out of the vein and prevent the blood from entering in the usual way. The vein will be empty and collapsed from the finger up to the first valve, since blood cannot flow backward down the arm in the vein past the valves. When the pressure of the finger is released, it will be seen that the vein quickly fills from the bottom up.

B-75. Pulse Rate [14, 13, 12]

Have several pupils take their pulse rate at rest and after vigorous exercise. Summarize the results in a table.

B-76. Effect of Temperature on Capillary Size (demonstration) [17, 11, 9]

Anesthetize a frog and spread out the web of a hind foot for microscope examination. After examining the capillaries in the web, put a small piece of ice on the foot. Observe again and note any changes in blood flow and/or size of the capillaries.

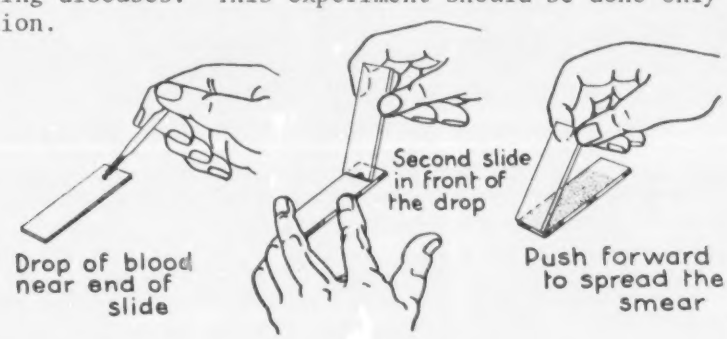
Remove the ice and after the foot returns to room temperature, drop some water warmed to 38°C on it. Examine again and compare circulation and capillary size with the conditions you observed at room temperature and when the foot was chilled.

B-77. Blood Cells [1]

Demonstrate the making of blood smears. To obtain blood for making a smear, press your thumb firmly near the tip of the ring finger of the left hand. With the right hand, grasp a sterilized needle near the point, and prick the tip of the ring finger quickly. Squeeze out a drop of blood and press it against a microscope slide near the end.

Draw a second microscope slide across the drop so as to spread it to the length of the first slide. Apply any stain, such as Wright's stain, allowing it to remain on the smear for one minute. Rinse the slide with water for three minutes and allow it to dry. Blood cells will show clearly when the slide is examined under high power.

Call attention to the fact that blood smears are used widely by physicians in diagnosing diseases. This experiment should be done only as a teacher demonstration.



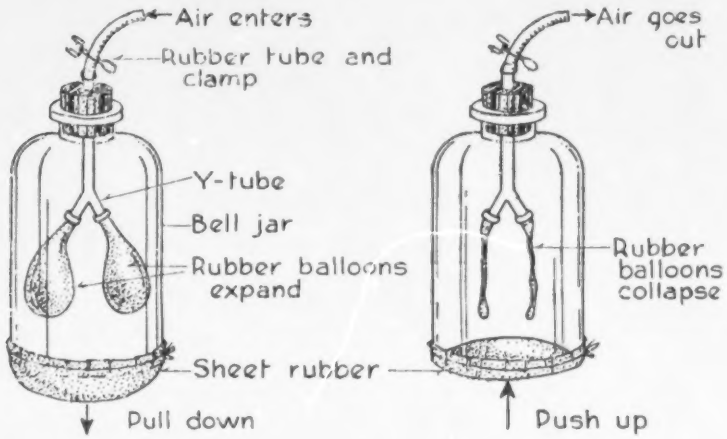
B-78. Producing Sound [2, 1]

Press the thumb and forefinger against the larynx and make a low-pitched sound with the voice. The sound vibrations will be felt very clearly.

Increase the pitch of the voice and note the difference in the feel of the vibrations.

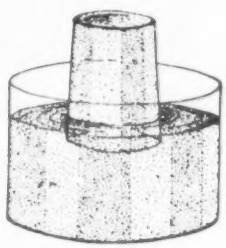
B-79. Mechanism of Breathing [14, 2, 1]

Demonstrate the action of the diaphragm by means of the apparatus shown in the diagram. The rubber balloons represent the lungs, the tube represents the trachea, and the open bottom bell jar represents the bony thoracic girdle. Lowering the diaphragm reduces the pressure inside the chest cavity and air flows into the lungs. Raising the diaphragm reverses the flow of air. Try moving the diaphragm with the clamp closed.



B-80. Air Pressure [14, 4, 1]

(a) Submerge a tumbler and allow it to fill with water. Turn it to an inverted position and lift it straight up until nearly all of the glass is above the water surface of the jar. The water does not run out of the glass because of the atmospheric pressure on the surface of the water in the vessel.



(b) Use a rubber tube as a siphon to transfer water from one vessel to another.

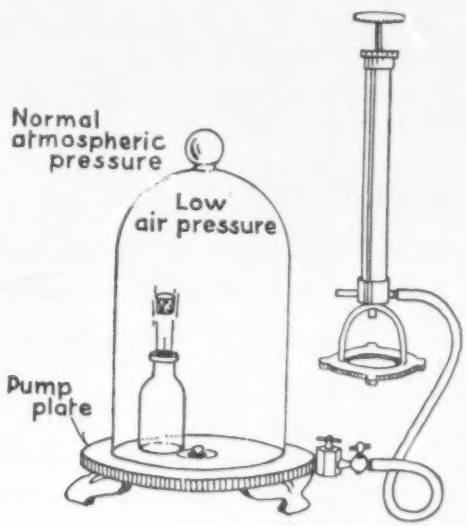
Fill the rubber tube by placing it under water or by holding it under a faucet. Pinch both ends and place them in separate vessels of water. Raise one vessel so that the water surface in it is above the water surface of the other vessel. When most of the water has been transferred from the first vessel, raise the second vessel.

Develop the understanding that atmospheric pressure on the water surfaces of both vessels keeps the siphon filled with water.

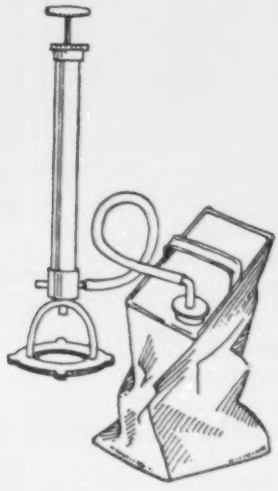
When two vessels filled with water to the same level are connected by a siphon no water flows because the pressure is the same on each side. Raising the first vessel increases the length of the column of water in the siphon on the side of the second vessel. Consequently, the pressure of the column of water in the siphon is now greater on the side of the second vessel, and the water flows until the columns are again the same length.

Cite several practical applications of the use of siphons.

(c) Place a corked bottle beneath a bell jar and exhaust air from the jar. The cork should pop from the bottle. (Some experimentation is necessary to find the right type of bottle and to determine the force with which to cork it.)



(d) Insert a one-hole stopper into a discarded gallon metal can (varnish, wax, or syrup can) and pump out the air with a vacuum pump. Atmospheric pressure will collapse the can. See diagram on the following page.



B-81. Volume of Our Lungs [7, 5, 12]

The volume of air inhaled per hour can be estimated quite accurately by each pupil in the following way.

a. Fill a large jug with water and invert it in a larger vessel containing a little water. Exhale through a rubber tube and determine the average number of normal exhalations that will empty the jug.

b. By using a graduated cylinder, find the volume of the jug (in liters) by filling the empty jug with a measured amount of water.

c. Determine the volume of one breath by dividing *a* into *b*.

d. Determine the average number of exhalations per minute by counting them.

e. The approximate number of liters of air breathed per minute is equal to *c* multiplied by *d*.

f. The number of liters of air breathed per hour will be approximately 60 times the number of liters breathed per minute.

B-82. Breathing Rate vs. Exercise [14, 13, 12]

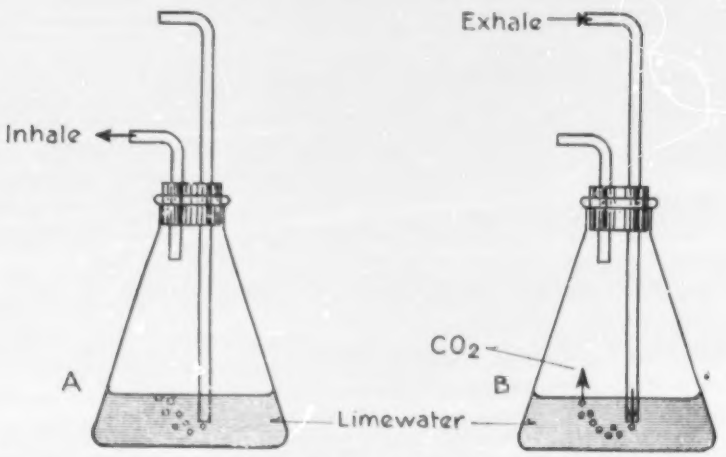
Find the breathing rate by counting the number of inspirations a minute. Jump up and down on one foot 20 times and count the inspirations in a minute again. (The normal rate of breathing varies from about 12 to 18 times a minute and is under automatic control.)

B-83. Carbon Dioxide Given Off by Lungs [16, 10, 9]

Set up the apparatus as shown in the diagram below and put about 2 centimeters of limewater in each flask. (Limewater turns milky in the presence of carbon dioxide.)

Inhale through the lower tube of flask A and exhale through the upper tube of flask B. This will cause the air to go through limewater before entering your lungs and again after leaving them. Continuing inhaling and exhaling through the limewater for 1 minute.

The limewater in the flask into which you exhale will quickly become very milky, while that in the other flask will become only very slightly milky, if at all. This is a controlled experiment situation that indicates clearly that the carbon dioxide in exhaled air comes from a body process.



B-84. Excretion of Water through Skin of Vertebrates [17, 13, 14]

Much water is excreted through the skins of vertebrates. This can be demonstrated with two live frogs and two battery jars or liter jars.

Weigh one of the jars when empty, then with one of the frogs in it. Subtraction will determine the weight of the frog. Do the same with the other jar and frog.

Add 2 to 3 centimeters of water to the jar with the first frog and cover it with screening so that the frog cannot escape. Put the second frog in its jar without water and cover it with screening.

After 24 hours reweigh the frogs by the same method as originally used. Compare these weights with the original weight of the frogs.

The results obtained are explainable because frogs inhabit relatively wet environments.

B-85. Kidneys of Vertebrates [1, 2]

In vertebrates, dissolved wastes are removed from the blood as it streams through the kidneys.

The kidneys in vertebrates are paired and are in the dorsal body wall. In fish, they extend almost the entire length of the body cavity on either side of the backbone. They are very difficult to remove because of their thinness. The kidneys of other vertebrates are more easily removed from the animal.

An attractive display can be prepared by mounting on glass plates in jars of 10 percent formalin the dissected specimens of the kidneys of fish, amphibians, reptiles, birds, and mammals. Include the major blood vessels that bring blood to the kidneys and those that remove blood. It may be necessary to include some of the surrounding tissues in the case of the fish kidneys.

Pig, beef, lamb, and chicken kidneys may be obtained at the butcher shop. One kidney can be bisected longitudinally and both halves mounted on a single plate to show both internal and external structure.

A pig kidney sectioned longitudinally shows the major regions of the kidney as illustrated in many textbooks.

B-86. Ammonia in Urea (demonstration) [11, 14, 6]

The action of the enzyme urease, which transforms urea into ammonia, can be demonstrated simply. Urea and urease are available from biological supply houses. Dissolve a small amount of urea in water and pour this solution into two beakers. Add a small amount of the indicator phenolphthalein to each beaker. When you add a few crystals of urease to one beaker, pupils will notice an immediate color change to red. This occurs because the solution is changed to alkaline by the ammonia that is formed.